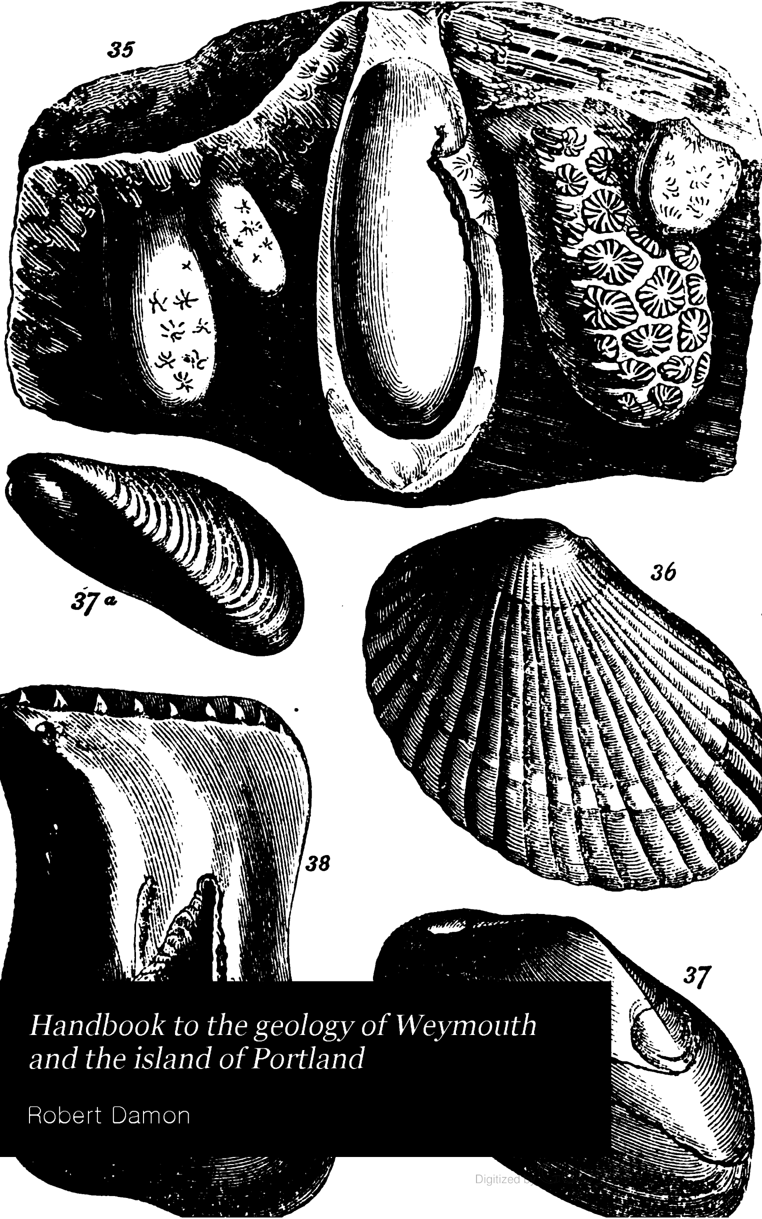

Handbook to the geology of Weymouth and the island of Portland

Robert Damon

Joseph Abel ~
Dorsetshire
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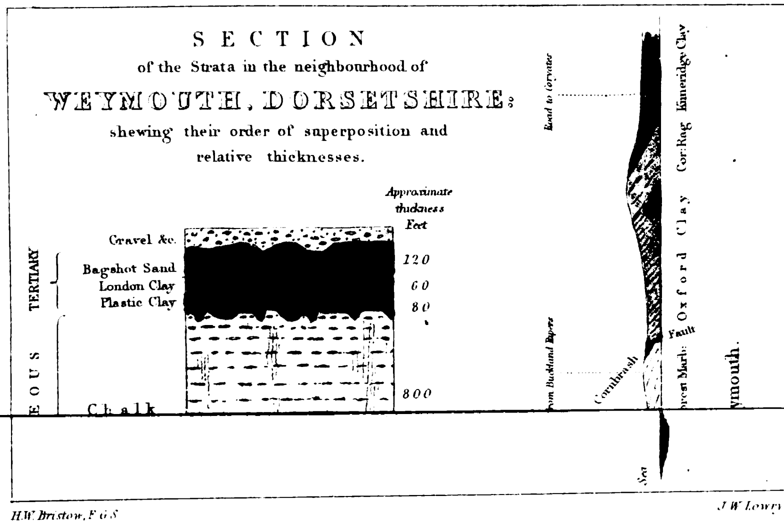
HANDBOOK

TO THE

GEOLOGY OF WEYMOUTH AND THE ISLAND OF PORTLAND.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET.


SECTION
of the Strata in the neighbourhood of
WEYMOUTH, DORSETSHIRE;
shewing their order of superposition and
relative thicknesses.
Approximate thickness Feet
Gravel &c.
Bagshot Sand 120
London Clay 60
Plastic Clay 80
Chalk 800
TERTIARY
EOUS
Road to Coryates
om Buckland Ripers
Kimeridge Clay
Cor: Rag
Oxford Clay
Fault
Cornbrash
orest Marble
ymouth.
Sea
H.W. Bristow, F.G.S.
J.W. Lowry.

HANDBOOK

TO THE

GEOLOGY OF WEYMOUTH

AND THE

ISLAND OF PORTLAND.

WITH NOTES ON THE NATURAL HISTORY OF THE COAST AND NEIGHBOURHOOD.

BY ROBERT DAMON.

ACCOMPANIED BY A MAP OF THE DISTRICT, GEOLOGICAL SECTIONS, PLATES OF FOSSILS, COAST VIEWS, AND NUMEROUS OTHER ILLUSTRATIONS.

LONDON:
EDWARD STANFORD, 6 CHARING CROSS.
1860.

PREFACE.

Although the maps and sections of the Geological Survey, distinguished no less for their beauty of execution than for their accuracy of detail, have greatly facilitated the study of the Geology of Weymouth and the Island of Portland, a guide to the Geology of the district in question, written in a somewhat scientific yet elementary and popular form, has long been demanded.

The excellent Memoirs, relating to this part of the county, by Mr. Webster, Dr. Fitton, Dr. Buckland, and Sir Henry de la Beche, contained in the Transactions of the Geological Society, commence at too advanced a point for the majority of persons.

An endeavour has been made in some measure to supply the above-mentioned want, by pointing out in the following pages where the various formations can be best examined, and by rendering the latter more easily identified by means of views, sections, and other illustrations.

An attempt is also made to furnish, for the first time, a complete record of the fossil remains of the neighbourhood: the most characteristic of these are figured, together with others now described for the first time.

A few notes are appended on Natural History and other collateral subjects not strictly of a Geological nature.

R. D.

Weymouth, 1860.

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LIST OF WORKS

Referred to in this Volume relating to the Geology of the Coast of Weymouth and the Isle of Portland.

Leland's "Itinerary," written in the year 1538, published 1769. Vol. iii.

"A Survey of Dorsetshire, containing the Antiquities and Natural History of that County," from an original MS., written by the Rev. Mr. Coker of Mapowder, published in the year 1732. The MS. bearing date April 3, anno 1653, but supposed to have been written between the year 1617 and 1633.

Hutchins' "History and Antiquities of the County of Dorset," 1774. 2 vols. folio.

Ditto, 2nd Edition. 4 vols. folio, 1796—to 1815.

"A Description of the Principal Picturesque Beauties, Antiquities, and Geological Phenomena of the Isle of Wight," by Sir H. C. Inglefield; with additional Observations on the Strata of the Island, and their continuation in the adjacent parts of Dorsetshire, by Thomas Webster, Esq. Illustrated by Maps and numerous Engravings. 1 vol. folio. London, 1816. Pp. 238, and fifty Plates. Published at 7*l.* 17*s.* 6*d.*

"On the Purbeck and Portland Beds, by Thomas Webster, Esq. Secretary of the Geological Society." Geo. Trans. vol. ii. second series, part 1, p. 31. Read November 19, 1824.

"Inquiries respecting the Geological Relations of the Beds between the Chalk and the Purbeck Limestone in the South-East of England." By Dr. Fitton. Annals of Philosophy for November, 1824.

"Outlines of the Geology in England and Wales. By the Rev. W. D. Conybeare and W. Phillips, Esq." 1 vol. 8vo. London, 1822.

"Observations on some of the Strata between the Chalk and the Oxford Oolite in the South-East of England," by Dr. Fitton. Pp. 286. Coloured Maps and Sections, and fourteen Plates of Fossils. Geol. Transactions, vol. iv. 2nd series.

"On the Beds composing the Cliffs between Portland Ferry and Weymouth Harbour," by Prof. Sedgwick. Annals of Philosophy for May, 1826.

"On the Cycadeoideæ, a Family of Fossil Plants found in the Quarries of the Isle of Portland." By the Rev W. Buckland, D.D., &c. Geol. Trans. vol. ii. 2nd series. Read June 6, 1828.

"On the Geology of the Neighbourhood of Weymouth and the adjacent Parts of the Coast of Dorset." By the Rev. Dr. Buckland and Sir H. De la Beche. Geol. Trans. vol. iv. new series. Read April 2 and 16, 1830.

"On the Geology of Ridgway near Weymouth." By C. H. Weston, Esq. Geological Proceedings, vol. v. p. 245, and p. 317.

"Geological Map of the South-West of Dorsetshire, being Map 17 of the Geological Survey of Great Britain." 1850.

"Geological Excursions round the Isle of Wight, and along the adjacent Coast of Dorsetshire." By Dr. Mantell. 1 vol. 8vo. 1850. New edition in Bohn's "Scientific Library." 1853. Price 5*s*.

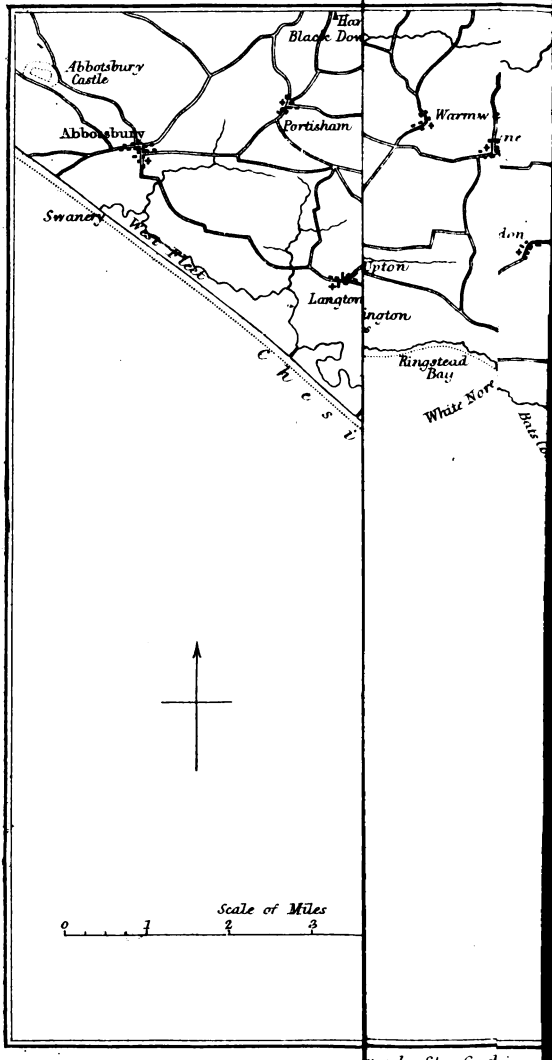
"On the Succession of Strata and Distibution of Organic Remains in the Dorsetshire Purbecks." By Prof. Edward Forbes, F.R.S. Proceedings of the British Association for the Advancement of Science, held at Edinburgh in August, 1850.

"On the Purbeck Strata of Dorsetshire." From the Transactions of the Cambridge Philosophical Society, vol ix. part iv. By the Rev. Osmond Fisher, F.C.P.S., F.G.S. Cambridge, 1855.

"On the Insect Beds of the Purbeck Formation in Wiltshire and Dorsetshire." By the Rev. P. B. Brodie, M.A., F.G.S. Geological Proceedings, vol. x. part iv.

"A Description of the Chesil Beach." By Mr. J. Coode, M. Inst. C. E. Read at the Institution of Civil Engineers, May 3, 1853.

"Sections to illustrate the Geology of the Isle of Purbeck, Dorsetshire." By Henry W. Bristow, F.G.S. Horizontal Section, Sheet No. 56. Published 1859.



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GEOLOGY

OF

WEYMOUTH AND THE ISLAND OF PORTLAND.

PHYSICAL FEATURES.

A PERSON seeing the country, now under consideration, for the first time, might naturally ask when the adjacent lands were lifted from their ocean-bed and fashioned into their present form of island, hills, and valleys, and by what agency was this effected? Such changes of the earth's surface were once considered as exclusively due to some force which attended its early history, but which has now altogether ceased, or acts with a greatly subdued power. It is now, however, considered more probable that the same agencies continue in operation and act with an equal degree of intensity at the present as at any previous times. The elevated lands surrounding Weymouth were probably raised to their present position not so much by one or more mighty convulsions as by the action of more gentle forces operating through long periods of time. It is thus that the solid portions of the earth are built up, while the sea in its ceaseless action wears down those parts which are exposed to its influence, as is seen in the encroachments made on this coast where cretaceous and other calcareous and yielding strata prevail. If the north and west coasts of Great Britain consisted of the same formations instead of the older and Plutonic rocks, it is evident that its geographical extent would be rapidly diminishing.* These two agencies illustrate that cycle of decay and renovation which the materials of the earth undergo, and by which the balance of land and water is maintained. The waste of its exposed parts is compensated by the solid particles that are removed being re-arranged at the bottom of the sea, and after a period of repose re-elevated to the surface to form new land.

Of the wasting and denuding power of the sea this coast furnishes ample illustration. The Chalk and softer strata having readily yielded to its action, have been worn away in a greater degree than the harder oolitic and other rocks. The different formations having thus yielded unequally, there have been formed curves, bays, natural arches, caverns, peaks, and insulated portions. Examples: Durdle or Barn-door Cove, Man-of-War Cove, Stare Cove, Lulworth Cove, Worbarrow Bay, &c.

Where the south-west frontier of the Chalk first rose out of the sea cannot now be determined, but it must have been considerably in advance of its present line. Probably the entire bay of Weymouth has been formed by the action of the sea on the yielding strata which may once have filled that area.

From Portland to the Land's End, where harder rocks prevail, the coast is more linear; but where the softer formations come in the coast line recedes.

* M. Elie de Beaumont affirms that a correspondence in the direction of mountain ridges, indicates correspondence in the direction of strata; *i.e.* all mountain chains raised during one period have the same course however remotely situated from each other, and in confirmation of his theory furnished a list of parallel systems already recognised. That of the Jurassic or oolitic being W. 26° N. From this approximate uniformity in the direction of mountain ridges, he infers that the rotatory motion of the earth has assisted in producing them.—Johnstone's 'Physical Atlas,' 2nd edition, p. 2; and Hopkins, 'Geo. Quarterly Journal,' vol. iv. p. 70.

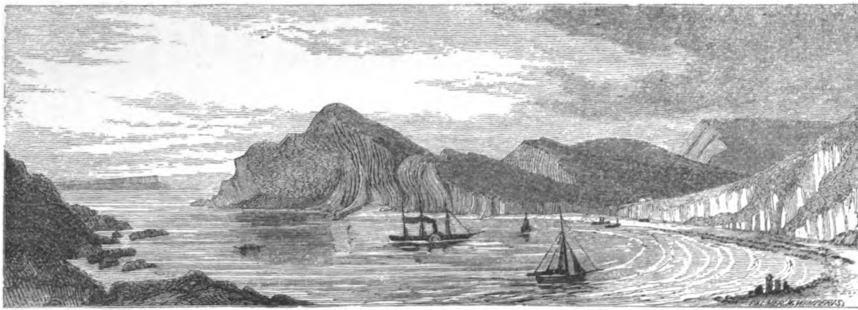


Fig. 1. LULWORTH COVE.

An almost circular bay or basin, about five hundred yards in diameter, and formed by the action of the sea on the receding Chalk. The rocks at entrance on both sides of the cove, being composed of the Portland and Purbeck strata, have been less affected. These last, as represented in Plate 1, are highly inclined and contorted, while the Chalk and Hastings sands are nearly vertical.

Durdle, or Barn-Door Cove, half a mile west of Lulworth Cove, Fig. 2. The most singular feature of this bay is the natural arch, known as the "Barn-door," formed in the Purbeck limestone, and sufficiently high for a good-sized sailing-boat to pass through it. The chalk strata composing the main cliff on the north side are almost vertical.

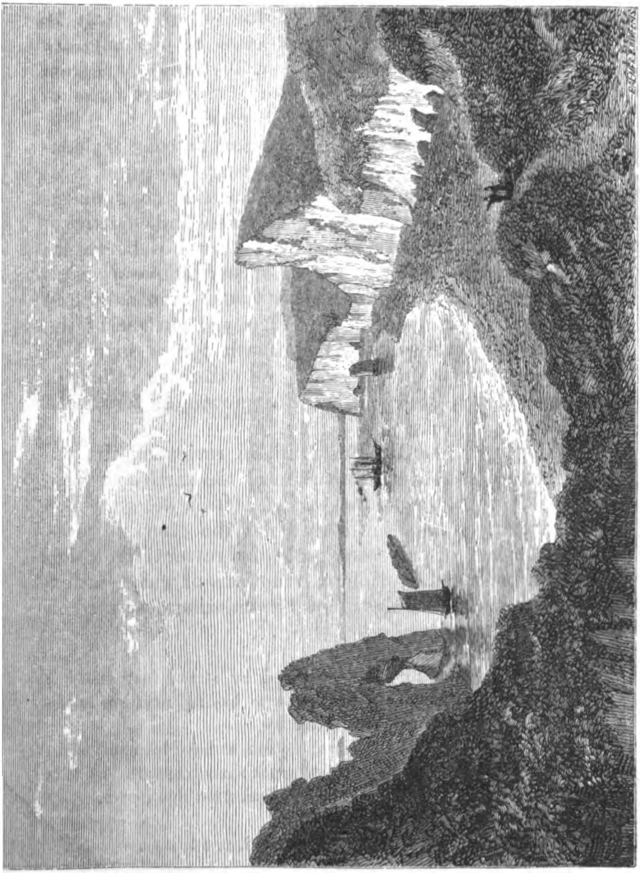


Fig. 2. Durdle, or Barn-door Cove.

The effects of denudation are throughout the district very visible, the entire surface being more or less traversed with valleys of denudation * and other hollows produced by this agency, the force of which can be estimated not only from the absence of the superior formations of Greensand, Chalk, and Tertiaries, but from the almost complete disappearance of the vast mass of materials which once filled up these intervals.†

These inequalities of the surface find an easy explanation in the theory now very generally accepted, viz., that as the land rose slowly out of the sea it became exposed to the violent agitation of the waves and currents of the ocean, which in places may have removed each stratum as it rose to the surface, while in others temporary lakes were formed, the waters of which would eventually find for themselves an outlet. The furrowed surface of the Chalk on the north-east of Weymouth agrees with this supposition; while on the west the extensive valleys of Burton, Bridport, Chideock, and Charmouth, all terminate at the sea.

The distinguished Dr. Buckland, in reviewing the various proofs of a recent inundation of the earth's surface, identifies it with the waters of the Mosaic deluge;‡ but at a later period (1837) he considered the event in question as the last of the many geological revolutions which have been produced by violent irruptions of water, rather than by the comparatively tranquil inundation described in the inspired narrative.§

* The term applied to valleys enclosed by strata that afford a correspondence of opposite parts; the name having reference to the agency supposed to have produced them.

† As the former contents of these valleys must have been lodged in an adjacent sea, the shingle on the Weymouth shore, composed as it is of chalk-flints, may have been partially derived from this source.

‡ 'Reliquiæ Diluvianæ,' 1824, p. 28.

§ 'Bridgewater Treatise,' 2nd edition, vol. i. p. 94, *note.*

Approximate Thickness of the Earth's Crust.*

	Feet.
Tertiaries	2,500
Cretaceous	2,400
Wealden	1,300
Oolite	2,250
Lias	1,000
Trias	3,000
Permian	1,000
Carboniferous	10,000
Devonian	10,000
Silurian	28,000
Non-fossiliferous rocks	15,000
	76,450 or 14½ miles.†

The *average* thickness of each series is here given; as it is not to be supposed that every formation maintains its maximum depth over any given area.

This thickness is not increased by the deposition of new strata, as these are but the redistribution of pre-existing materials. Though the tertiary and secondary rocks go to swell the above estimate by 12,000 feet, there are extensive districts where the palæozoic strata have been denuded to that depth.

Abridged Table of Fossiliferous Strata.

(Sir C. Lyell's Arrangement.)

1. Post-Tertiary.

Recent.
Post-pliocene.

* The strata composing the crust of the earth have been compared to the concentric layers of an onion; but as no one stratum has ever enveloped the entire globe, the illustration though striking is not strictly correct. The sedimentary rocks were deposited in basin-shaped depressions.

† From the top of Chimborazo to the bottom of the Atlantic, at the deepest place yet reached by the plummet, the distance in a vertical line is nine miles.—Maury's 'Physical Geography of the Sea,' p. 251, 2nd edition.

2. Tertiary, or Cainozoic.

Pliocene. . .	Newer pliocene.
	Older pliocene.
Miocene . .	Upper miocene.
	Lower miocene.
Eocene . .	Upper eocene.
	Middle eocene.
	Lower eocene.

3. Secondary or Mesozoic.

Cretaceous . .	Maestricht beds.	
	Upper white chalk.	
	Lower white chalk.	
	Upper greensand.	
	Gault.	
	Lower greensand.	
Wealden . . .	Weald clay.	
	Hastings sands.	
Oolite	Upper oolite	Purbeck beds.
		Portland stone and sand.
		Kimeridge clay.
	Middle oolite	Coral rag.
		Oxford clay.
	Lower oolite	Great or Bath oolite.
		Inferior oolite.
Lias	Lias . . .	Upper.
		Middle.
		Lower.

Trias (Upper new red sandstone):

Upper trias.
Middle trias, or Muschlekalk.
Lower trias.

4. Primary, or Palæozoic.

Permian . . .	Upper permian (Magnesian limestone series).
	Lower permian (lower new red sandstone.

Carboniferous .	Coal-measures.
	Millstone grit.
	Carboniferous, or Mountain limestone.
Devonian, or old red sandstone:	
	Upper Devonian.
	Lower Devonian.
Silurian	Upper Silurian.
	Lower Silurian.
Cambrian . . .	Upper Cambrian.
	Lower Cambrian.

It will appear that the formations of this district belong chiefly to the oolitic,* so-called from many of the limestones of this series being composed of small round particles or grains like the roe of a fish, the nuclei of which have in some instances been resolved by the aid of the microscope into a fragment of shell or other organic remain. Some of the Portland beds are very characteristic of this oolitic structure. The group of strata described as oolitic in England is better known on the Continent under the term Jurassic. The Jura mountains are in part composed of beds equivalent in age to those of the oolites of Great Britain, although sometimes differing in lithological character—the oolitic rocks of the Alps, being as hard as granite. In Great Britain the oolitic series ranges from the coast of Dorsetshire through the centre of the county to the coast of Yorkshire, and reappears in the north of Scotland and north of Ireland. It is developed on the opposite coast of France, where it offers a close resemblance to the corresponding strata of Dorsetshire. It prevails also in parts of Germany and Russia. In the Crimea it presents on the sea-coast steep cliffs of limestone, pierced by eruptive rocks. In Spain† and on the Mediterranean coast and in Italy, it forms some of the higher parts of the Apennines. Recent discoveries of fossil

* From ωον an egg, and λίθος a stone.

† The oolites of Spain abound in metalliferous deposits, and contain beds of which were formerly worked with a profit.—Esquezza 'On the Geology of Spain.' 'Geo. Pro.' vol. vi. p. 408.

remains in Northern Hindostan, the Himalaya mountains, and other parts of India go to show that the Oolites are also represented there. At Cutch, in the north-west part of India, beds similar to the British Oolites were discovered by Captain Grant,* and Captain A. Gerard here collected ammonites 16,200 feet above the sea. Sir John Richardson, in his last Arctic searching expedition,† brought fossils from the bed of the Mackenzie river, which were referred by Mr. Sowerby to the Oxford Oolite. The existence of Jurassic deposits on the east coast of Africa is also established. ('Geo. Pro.', vol. xv. p. 17.) The Oolites yield the principal building-stones of the middle and south of England, and include the Purbeck, Portland, and Bath. Caen stone is similar to the Bath, and the celebrated lithographic stones are worked from the Upper Oolite of Solenhofen. The beautiful statuary marble of Carrara in Italy, once supposed to be a primitive limestone (*i. e.*, formed before the existence of organized beings), is now known to be an altered oolitic limestone—its crystalline texture, clear whiteness, and absence of fossils being caused by subterranean heat. The oolitic series of Sutherlandshire lies beneath masses of granite. In parts of Italy where oolitic limestones abound, it is found that their texture resemble that of the Carrara marble in proportion as they are pierced by igneous rocks. Had the force which lifted Portland from the bed of the sea been accompanied, as in the raising of the Alps, with eruptive matter forcing a passage through the superincumbent strata and under great pressure, Portland might also have yielded beds of crystalline marble.

The Oolite which extends from the coast of Yorkshire to that of Dorset is at no one point so completely developed as in this district, where all the beds from the uppermost bed to the Forest Marble are present. In many places the oolitic rocks are irregular and unconformable. Thus in the vicinity of Oxford, the Coral Rag and Calcareous

* 'Geo. Pro.,' vol. v. p. 290.
† Vol. i. p. 177.

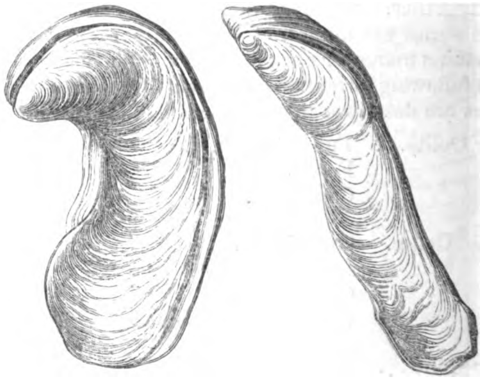
Grits rapidly thin out until they disappear, and the Kimeridge clay (the formation above) rests on the Oxford clay. Near Swindon the Coral Rag occurs only at intervals, hence the Kimeridge clay and Oxford clay often come together. While in other districts certain members of the series are absent, at Weymouth each is present, and attains moreover almost its maximum thickness.

The following formations represented in the Weymouth district are described in their ascending order :—

Lower Oolite. .	Fullers' earth. Forest marble. Cornbrash.
Middle Oolite.	Oxford clay. Lower calcareous grit. Coral rag. Upper calcareous grit.
Upper Oolite. .	Kimeridge clay. Portland sand. Portland stone. Purbeck beds.
Wealden. . .	Hastings sand.
Cretaceous. .	Gault. Upper greensand. Chloritic marl. Lower white chalk. Upper white chalk.
Tertiary. . .	Plastic clay. Newer pliocene. (Bone caverns.)
Post-Tertiary .	Mammaliferous deposits. Chalk, flints, and breccia. Sandstone, boulders, Druid-stones. Raised beaches. Land-slips, sea-waste, atmospheric debris.

FULLERS' EARTH. (Characteristic fossil.)

Fig. 3. *Natural size.*



Ostrea acuminata, Sow. (Aberrant forms).
From the Fullers' Earth, Langton, Weymouth.

This is the lowest or oldest formation, brought to the surface within twelve miles of Weymouth,* and consists of clayey beds attended with a layer or layers of 'Fullers' earth.' Its nearest point is a small portion of the cliff at Langton, on the shore of the Fleet, five miles west from Weymouth. It reappears at Abbotsbury, and from thence extends without interruption along the coast to Burton Castle, two miles east of Bridport harbour. Its distinguishing or characteristic fossil is a small oyster, the *ostrea acuminata*, generally very abundant: at Langton the cliff is little else than a mass of this one species. The site of this singular accumulation is the bank or cliff immediately below the Coast-guard station. In some localities the Fullers' earth is found to contain other fossil shells of

* In the frontispiece the Inferior Oolite is placed at the base of the vertical section of the Weymouth strata, but this formation does not occur nearer than Burton Bradstock.

species belonging either to the Great Oolite above or the Inferior Oolite beneath. *Ostrea acuminata*, however, is the only species I have noticed in this neighbourhood.

FOREST MARBLE. (Characteristic fossils.)

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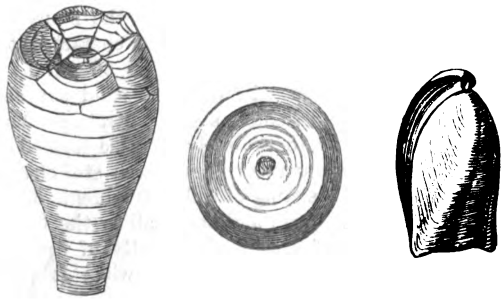


4. *Terebratula digona*, Sow. Natural size.
5. *Apiocrinites rotundus*, Miller. Slightly reduced. (Pear Encrinite.)
6. Section of ditto.

Weymouth.

The Forest Marble comprises both layers and blocks of limestone, divided by thin seams of clay and calcareous bands. The limestone portion, or that commonly known as the 'Forest Marble,' is so fissile and slaty as to supply roofing and flagstones for the villages near which the stone occurs. In Wychwood Forest, Oxfordshire, a portion of it assumes a crystalline texture, and when worked and polished forms the coarse marble from which the formation takes its name. It has been observed that bivalve shells are most common in the thick beds, univalves in the thin.*

Its horizontal extension here is considerable, rising from beneath the Cornbrash, at Radipole and Nottington,

* Referring to this formation in Dorsetshire, Mr. Conybeare remarks that it seems more probable that the Great Oolite passes into the fissile character of the Forest Marble, than that the Forest Marble (generally a subordinate bed only) should here attain such a disproportionate thickness, and the Great Oolite itself be absent.—'Outlines of Geology,' p. 205.

it extends westward to the coast at Abbotsbury, with an average width of two miles, and a thickness of 500 feet. It is quarried for flagstones, sometimes for building and for road-metal. Organic remains are generally abundant, many of the thin stony beds being composed of fragmentary shells. The best-preserved specimens are from the seams of clay which alternate with the stony beds. The waved and wrinkled appearance so characteristic of the Forest Marble, answers to examples offered at the present day by the furrowed surface of sand exposed at low tides on a flat and shallow shore. Strata presenting such an appearance were probably likewise formed on a shallow shore. Their analogy is rendered still closer by their composition consisting of rolled fragments of *shells*, *corals*, *echini*, and *crustacea*; and above all by the frequent impression of small footsteps, apparently of crabs and annelids which frequented the shore when it became exposed by the ebbing of the tide.

List of Fossils from a Quarry of Forest Marble near the higher mill at Radipole—where we meet with the following section:—

a. Soil—1 foot.

b. Whitish clay which, towards the middle and lower part, contains flags of hard bluish limestone, frequently covered with shells, both whole and fragmentary. This is highly characteristic of the Forest Marble—12 feet.

c. Solid beds of stone—4 feet, forming the bottom of quarry, and probably extending to much greater depth.

Apiocrinites rotundus.
Trigonia pullus, Sow.
Pholadomya Heraulti, Ag.—a small variety.
Rhynchonella concinna, Sow.
,, *varians*, Schloth.

* This stratum known as the 'Bradford Clay,' is regarded by some authorities as a sub-formation, separating the Forest Marble from the Great Oolite.

Terebratula digona, Sow.—abundant.
„ *perovalis*, Sow.
„ *intermedia*, Sow.
Fragments of *Pentacrinus and lignite.*

FOREST MARBLE.—NOTTINGTON.

At Nottington, a village three miles north of Weymouth, where the Forest Marble is quarried, there is the following section displayed in a quarry situated immediately off the main road, about 100 yards beyond the mill.

a. Soil—1 foot.

b. Clay—5 feet.

c. Alternately layers of clay and soft sandy stone—4 feet.

d. Clay—2 feet.

e. Stone—2 feet.

f. Blue clay—1 foot 3 inches.

g. Good stone, bluish, shelly, crystalline, hard, less fissile than the stony beds of the Forest Marble usually are—7 feet.

h. Blue clay—bottom of quarry.

List of Fossils, several of which are Cornbrash species.

Pecten hemicostatus, Lyc.
Lima duplicata.
Terebratula intermedia—abundant.
Rhynchonella varians.
Ostrea gregaria, Sow.
Myacites decurtatus.
Apiocrinites.
Small shells and lignite on flag-stones.

FOREST MARBLE AT LANGTON HERRING.

In a quarry between the village and the Coast-guard station a good section is offered, which differs from that at Radipole.

a. Soil—1 foot.

b. Clay, but without the Terebratula digona, which is so numerous in this bed at Radipole—1 foot 6 inches.

c. Stone, in layers one and two inches in thickness. Greyish when fractured, and composed, in great part, of comminuted shells—9 feet, bottom of quarry.

Fossils are numerous on the surface of the flagstones, chiefly of the genera *Pecten* and *Ostrea*; with portions of *Apiocrinites*.

Cornbrash quarries are close by.

The Forest Marble and Cornbrash formations, although in close proximity, are very dissimilar in lithological character; but the presence of the characteristic species of fossils figured will be found a useful and sure means of identification.

In a quarry of Forest Marble at Well Down, a little east of the village of Abbotsbury, fossils are numerous, chiefly of the following species:—

Apiocrinites rotundus, (oscicles).
Rhynchonella obsoleta.
" *farcta*.
Terebratula intermedia.
Ostrea Sowerbyi.
Cidaris, (*spines*).

CORNBRASH. (Characteristic Fossils.)

Fig. 6.

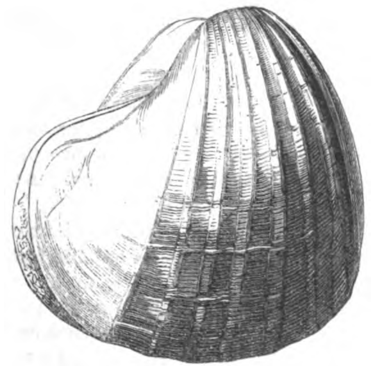


Fig. 7

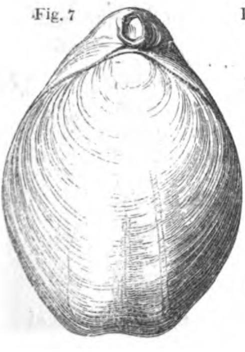


Fig. 8

Fig. 10

Fig. 9

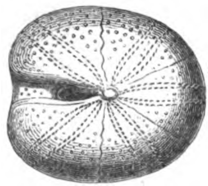


Fig. 10a

6 *Pholadomya bucardium.* Ag. Reduced.
7. *Terebratula intermedia.* Natural size. 10. *Avicula echinata.* Natural size.
8. „ *obovata.* do. 10a. *Nucleolites clunicularis.*
9. *Rhynchonella concinna.* do.

All from the Cornbrash, Weymouth.

In immediate contact with the Forest Marble, with which it is generally asociated, is the Cornbrash (so called from its breaking up or disintegrating into small rubble,)* which becomes well adapted for the growth of corn, and yielding, in comparison with other stone-brash lands, much better crops.†

It is a coarse rubbly limestone, of a grey or bluish colour, generally in flattish or lenticular masses, yielding stones seldom exceeding a foot in diameter, and of but little value as building-stone. Partings of brown and greyish clays alternate with the more solid beds. At Weymouth this formation is forty feet in thickness.

Geologically considered, the Cornbrash is an unimportant formation, easily recognised by its organic remains, which are extremely numerous. Phillips, in the 'Geology of Yorkshire,' remarks 'that it is not so much by the presence of particular species of fossils which are found in no other stratum, that the Cornbrash can be accurately

* '*Brash*, a provincial expression used to designate any stony soil, is derived from the Saxon, *brecan*, to *break* (whence bræc, broken).' 'A Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology,' p. 77, by H. W. Bristow, Esq.

† Analysis of the Cornbrash by Professor A. Voelcker:—

Carbonate of lime	89·195
Magnesia	0·771
Sulphate of lime	0·241
Alumina	2·978
Phosphoric acid	0·177
Soluble silica	1·231
Insoluble siliceous matter	4·827
Alkaline salts (undetermined)	
	99·423

The agricultural capabilities of cornbrash lands may be judged from the rent-charge in the county of Gloucester, quoted by Professor Buckman in an able paper, on 'The Oolite Rocks of Gloucester and North Wilts,' Geo. Proc. vol. xiv. p. 98.

1*st*.	Rent of stonebrash,	inferior oolite,	from	7*s*. to 20*s*.	the acre.
2*nd*.	„	great oolite,	„	14*s*. „ 25*s*.	„
3*rd*.	„	cornbrash,	„	20*s*. „ 40*s*.	„

identified, as by the occurrence together in it of some fossils which are repeated in rocks above, and several others which are found in those beneath.' Confirmatory of this opinion, Professor Buckman observes that every fossil figured by Phillips, illustrative of Cornbrash, equally well illustrates the Inferior Oolite of Gloucestershire.

A good section may be noticed near the second mile-stone on the road to Dorchester (the eastern termination of a zone about half a mile in width, passing through the villages of East and West Chickerell to the Fleet backwater), and in a narrower but almost parallel zone extending from Nottington through Tatton to Langton Herring. It is throughout characterized by the same fossil remains, chiefly bivalves, of which the Brachiopoda are the most numerous. The channel of the backwater near the village of Radipole has been formed through the Cornbrash. The low cliffs on either side are favourable points for examining this formation, the stony beds of which are highly charged with fossils. In an adjoining field the upper stratum has been opened, for the purpose of quarrying stone for ballasting the adjacent railroad.

List of Fossils which may be expected to occur here—

Palatal teeth of *Fishes*.
Portions of *Crustaceæ*.
Rhyncholites (Sepia-beaks).
Holectypus depressus, Lam.

Mollusca.

Ceromya concentrica, Sow.
Pholadomya bucardium, Ag. Common.
,, *carinata*, Ag.
Ostrea Sowerbyii, Mor. and Lyc.
,, *costata*, Sow.
Gervillia. (?)
Lima duplicata, Sow.
Modiola cuneata, Sow.
Pecten, (*P. hemicostatus*, Lyc. and Mor.)
Avicula echinata, Sow.

Myacites (*Amphidesma*) Phil., *decurtatus*, Goldf.
„ „ *securiformis*, Phil.
Rhynchonella concinna, Sow.
„ *obsoleta*, Sow.
* *Terebratula obovata*, Sow. Com.
„ *intermedia*, Sow. Com.
Serpulæ.
Lignite.

In a quarry at Buckland Yoleys most of the above-named species are met with (*Pholadomya bucardium* and *Myacites decurtata* unusually abundant), and are repeated in another quarry near Tatton, about two miles west from Nottington. Numerous other quarries and road cuttings in the Cornbrash may be seen, but the formation is very uniform, both lithologically as well as zoologically.

OXFORD CLAY.†

(Clunch Clay of Smith, 'Strata identified.')

Characteristic Fossils.—See Plates of Fossils 1, 2, 3, 4.

The name of this formation is derived from its occurrence in the vicinity of Oxford, where it forms the substratum of the valley of the Isis. Dr. Buckland and Sir H. De la Beche estimated its thickness in this district at 300 feet.‡ The Geological Survey assigns to it a thickness of nearly 600 feet. It is closely associated with the Kimeridge clay. There is, however, no probability of the two being confounded, if the range

* *Terebratula* (including its recent subdivisions) as far as is at present known, is the only genus of mollusca found in the earliest fossiliferous strata, repeated in almost every subsequent formation, and having its representatives in existing seas. The same species frequently pass through successive formations, but when once lost sight of, in no instance have they reappeared.

† L'Argile de Dives is the name for a clay on the opposite coast of Normandy, corresponding to the Oxford clay of Britain.

‡ Dr. Buckland and De la Beche, 'Memoir on the Geology of Weymouth.'

of each stratum is understood; and the presence of two or three characteristic fossils is moreover decisive. Thus the common flat oyster, *Ostrea deltoidea*, Fig. 31, marks the Kimeridge; the curved oyster, *Gryphea dilatata*, Fig. 7, Plate 3, the Oxford clay. This latter clay is generally of a dark-blue colour, though not uniformly so, its upper portion being sometimes brownish. Its boundary on the east of this district is marked by the conspicuous land of Ham Cliff, whence it runs conformable to and follows the course of the Coral rag to its western termination at Abbotsbury; southward through Jordan Hill, Lodmoor, and Greenhill to Weymouth harbour (its southern boundary); and proceeds westward to the shore of the East Fleet. The displacement of strata in the Weymouth district is marked by the Oxford clay being adjacent to the coral rag on the south, as it is to another belt of Coral rag on the north, the intermediate distance being occupied by the Forest marble and Cornbrash. See Frontispiece.

Again, as the first vertical shaft of the long tunnel on the Dorchester railway passes through the Oxford clay, and that part of the hill is 300 feet above the level of the sea, it follows that the Oxford clay at Ridgway is but little short of that height above the Oxford clay at Weymouth. As, at the period of its deposition, it formed a continuous and horizontal stratum, this portion must have been raised into its present anomalous position viz., between the Hastings sands on the south, and the Chalk and Greensand on the north, instead of the Cornbrash and Coral rag. Its appearance between strata of so much later a period is so remarkable that doubts were entertained as to its identity, but the following list of fossils, nearly all of which are well-known Oxford clay species, places it beyond doubt.*

* The uniformity of the zoological character of the Oxford clay in districts widely remote, is evidenced by the presence of the same species in Great Britain, Wurtemburgh, Russia, South Africa. *Gryphæa dilatata* was found by Dr. Smith in Oxford clay on the banks of the Orange River in South Africa ('Geo. Pro.'), and it is the characteristic fossil here and in the before-named countries.

Fig. 11

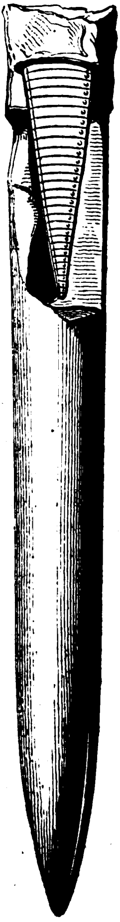


Fig. 12

Fig. 13

11. **_Belemnites Owenii._ Pratt. Reduced.**
12. **„ _hastatus._ Blain. Half nat. size.**
13. **„ _gracilis._ Phillips. Nat. size.**

All from the Oxford clay, Weymouth.

Gryphœa dilatata.
Ostrea Marshii.
„ another species
Anomia.
Nucula
Trigonia clavellata.
Myacites.
Pholadomya.
Astarte.
*Thracia depressa.**
Modiola bipartita.
„ another species.
Ammonites catena.
„ *Arduensis*
„ *Mariœ.*
„ *Lamberti*

In reply to another attempt to account for the occurrence of the Oxford clay in such an unlooked-for situation as a drift, Mr. Weston makes the following conclusive observations:

1. That the fossil bones found bear no marks of abrasion which would indicate their having been drifted.
2. That the Oxford clay is of considerable depth, 60 feet having been reached without arriving at its termination.

* This list of fossils is taken from a communication on the Geology of Ridgway, by Charles H. Weston, Esq. 'Geo. Pro.,' vol. iv. p. 245.

3. That the vertical surface of the wall of chalk is not consistent with the natural results of previous diluvial action in the locality under consideration.
4. Whence could the Oxford clay have drifted? There being no exhibition of that bed in the neighbourhood at so high a level.*

The Oxford clay, like the Kimeridge, contains beds of inflammable shale, though of less strength than the latter. Our friend Mr. MacNeil, of Trowbridge, has, in the course of his experiments, lit his establishment with gas obtained from the unctuous shale of the Oxford clay of that neighbourhood. Iron pyrites † is largely diffused, frequently incrusting organic remains, of which there are examples in the numerous small ammonites that occur in this formation. In this latter condition, we have an illustration of the production of iron pyrites by the decomposition of animal matter.‡ The sulphurous springs at

* Ibid.

† *Iron Pyrites.*—A natural product common to most of the clays and shales of the secondary period. Sulphur and iron exist in various combinations in great quantities all over the world; one compound is the well-known mineral *iron pyrites*, otherwise called *sulphide of iron*, *mundic*, &c., and occurs in the Oxford and Kimeridge clays of Weymouth. It is an article of commerce worth 15*s.* a ton, and yields above one-third sulphur and two-thirds iron. Its colour is different shades of brass-yellow: hence in these days of gold-searching it has been frequently mistaken for the precious metal. Iron pyrites is also used largely in the production of green vitriol and sulphuric acid.

‡ Mr. Pepys ('Geo. Trans.,' 1st series, vol. i.) records the accidental discovery of the production of iron pyrites from the decomposition of the bodies of some mice, which had fallen into a pitcher containing several quarts of a solution of iron that had remained unnoticed for a twelvemonth. Since then a similar instance occurred at the bottom of a mine in Cornwall, where a dog having fallen into a solution of sulphate of iron, its body became afterwards surrounded by iron pyrites. In these and other similar cases, the hydrogen evolved from the decomposition of the animal matter is considered to take the oxygen both from the sulphuric acid and oxide of iron, so that iron pyrites, or bi-sulphuret of iron, is formed.—De la Beche, 'Geol. Observer,' note, p. 600.

the Radipole and Nottington Spas near Weymouth derive their chemical character from the decomposition of this mineral in the alkaline sulphates of the shaly beds of the Oxford clay. Disengaged gases are sometimes detected, arising from the same cause.

Selenite, a crystallized form of sulphate of lime, produced by the action of decomposing iron pyrites upon the fossil shells, is abundant throughout this formation. Its ordinary form is a lenticular crystal, from one to three inches in length, soft, transparent, and easily splitting into thin plates or laminæ, when it is flexible like talc, a mineral substance found in the older formations.*

SEPTARIA (from Septum, a fence or division) are numerous throughout the Oxford clay in the Radipole backwater, also at the Greenhill, where they have formed in successive layers. None present the same beautiful markings as those met with at the first-mentioned spot. Cut into slabs and polished they form suitable tops for fancy tables, and great numbers are thus prepared. Though locally termed 'pudding-stone,' they are essentially different from the conglomerate known by that name, and which, from its abundance in the county of Hertfordshire, forms a feature in the geology of that district. The term, as applied to Septaria, is used to denote their form and structure; to the conglomerates of Hertfordshire, their composition, the latter being composed of gravel and flint pebbles in a siliceous cement, so mixed as to suggest the above epithet.

* Selenite is one of the forms of sulphate of lime, whence plaster of Paris is derived. As fibrous gypsum it occurs in Derbyshire, where it is worked into various ornaments. As a soft chalky stone, there are inexhaustible beds in the neighbourhood of Paris. In the island of Purbeck, blocks of gypsum are worked in the cliffs, and exported for making plaster of Paris. In its granular or more massive form it is better known as alabaster, which in Italy yields that well-known and beautiful material which is turned in the lathe, and sculptured into figures and vases. The celebrated Assyrian sculptures from the ruins of Nineveh are formed from slabs of gypsum. ('The plains of Mesopotamia abound in alabaster or gypsum.'—*Layard's Nineveh*, 1st series, vol. ii. p. 254.)

The name '*turtle-stone*' has been given from a supposed resemblance of the surface, when polished, to the back of a turtle. These are composed of indurated clay, with veins of calcareous spar (carbonate of lime),* the dark rich colour of which results from the presence of oxide of iron.

Notwithstanding the irregular veining, so that no two are alike, there is a general pattern which they all appear to follow. Thus in the larger or star-stones the centre is filled with spar, from which it radiates towards the edge or outside in a number of points not unlike those marked on a mariner's compass, each apex or point being about equally distant from the centre. Microscopic examination has detected the laminæ of the hardened clay to be parallel to the laminæ of the shale or marl in which the stones are enclosed. In some, where the crystallization is incomplete and a space remains, water is found. Whence is derived the water? The outer part of the stone is so dense and thick that it would appear impossible for it to percolate from without into the interior,† yet at an earlier stage of its formation, one of the numerous veins might have communicated with the surface of the stone before it had received its coating, and the smallest opening—no larger than a needle's point—would be sufficient for the infiltration to take place. Sir H. De la Beche,‡ referring to the probable mode of formation of these and other nodular concretions, supposes that, during the deposition of the stratum in which they occur,

* The septaria found in such profusion in the London clay of the island of Sheppey, Harwich, and other places, are, after being calcined and ground, made into Roman cement, and a similar material known as Parker's cement.

† Water is occasionally found in small cavities of basaltic rocks. Either the water originated with the formation, or has been drawn by capillary attraction into minute fissures from the exterior; or when the combination of the solid parts took place, the elements of water were present, and subsequently water has been formed.—(See Geo. Pro. vol. xxvi. p. 34.)

‡ 'Geological Observer,' 1853, p. 597.

the particles of carbonate of lime separated themselves from the muddy mass in which they were held in suspension, and accumulated at different points at or at about the same level. This gathering together of similar matter, distributed through a soft mass, is seen in the formation of crystals of selenite, iron pyrites, flints, and other nodules. In the case of septaria, he supposes that after the aggregation had taken place, and while the nodules were in the course of consolidation, a contraction of the interior took place, the cracks not extending to the outer surfaces, so that the largest openings were central. In such cases the cracks would become filled and form veins, the contents of which would vary according to the nature of the deposit of which the concretions formed a part. On the north shore of Weymouth small hard nodules, known as 'kidney-stones,' formed of reddish-brown clay with veins of spar, not unlike the septaria, are washed out of the cliff. Other nodules, of the dimensions of small cannon balls, are common in the Oxford clay at Boulogne, and are used for making a superior description of Roman cement.*

Ham Cliff.—Here the fossils are numerous, though generally compressed, and difficult of identification. The formation is traversed by lines of separation (joints) about one foot apart, inclined at an angle of 45°, and running transversely to the plane of stratification.

* For every 100 parts these nodules contain—

Carbonic acid . . .	36
Lime	34·50
Silica	15
Iron	7
Alumina	4·75
* * * *	2·75

From a MS. in the Museum of the Town College of Boulogne.

LIST OF FOSSILS FROM HAM CLIFF.

Crustacea.

Glyphea.

Cephalopoda.

Ammonites vertebralis.	*Ammonites Williamsoni.*
,, *Lamberti.*	,, *striolaris.*
,, *crenatus.*	,, *Gowerianus.*
,, *hecticus.*	,, *cordatus.*
,, *macrocephalus.*	,, *flexicostatus*, Phil.
,, *annularis.*	*Belemnites gracilis.*
,, *vertumnus.*	,, *hastatus.*
,, *Gulielmi.*	

Gasteropoda.

Alaria (*Rostellaria*) *trifida.*
Cerithium Damonis. N. sp.

Conchifera.

Ostrea Marshii, Sow.
,, A small species.
Gryphæa dilatata.
,, (*Exogyra*) *virgula.*
Pecten. A small species.
Nucula ornata.
Arca Quenstedtii, Lyc. (*A. æmula.* Quenst.)
Astarte carinata, Phil.
,, *zonata*, Romer.
Perna mytiloides.
Pinna.
Cardium. A small species.
Modiola bipartita.
Myacites.

Echinodermata.

Stems of *Pentacrinus.**

* A beautiful fossil when found entire, as in the Lias at Lyme Regis. Detached portions are known as Fairy Stones and St. Cuthbert's beads. Dr. Mantell found a series of them which had been worn as ornaments in tumuli of the ancient Britons.

FOSSILS OF THE OXFORD CLAY, WEYMOUTH.

Fig. 14

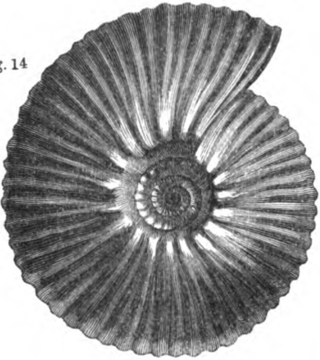


Fig. 15

Fig. 16

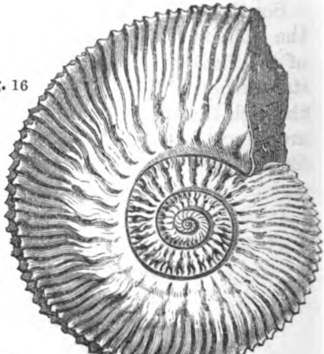


Fig. 17

Fig. 21

Fig. 18

Fig. 20

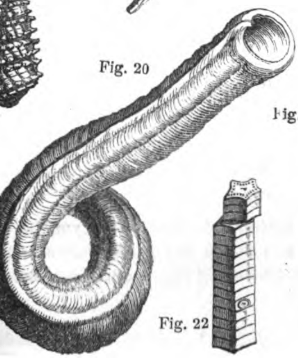
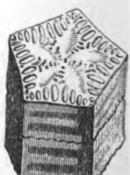


Fig. 19

Fig. 22

Fig. 23



Vermilia sulcata.	*Vegetable impressions.*
Serpula vertebralis.	*Lignite.*

OXFORD CLAY.—Weymouth Harbour.

Fig. 14. *Ammonites sublævis.* Sow. Reduced,
— 15. „ *Leachii.* Nat. size.
— 16. „ *Jason.* Slightly reduced.
— 17. „ *crenatus.* Brug. Nat. size.
— 18. *Cerithium Damonis.* N. sp. Nat. size.
— 19. *Alaria trifidia.* do.
— 20. *Vermilia sulcata.* Sow. do.
— 21. *Serpula vertebralis.* do.
— 22. *Pentacrinus.* do.
— 23. *Ditto.* Portion magnified.

South of the Greenhill this formation does not come to the surface,* but it may be seen at low water on the shore of the harbour of which it forms the bed. Between this, its southern termination, and the Greenhill, it is reached through beds of shingle and sand, when the excavations are carried to a sufficient depth to pierce through the former deposits; hence it will be seen that the Oxford clay is the water-bearing bed of the town.

In deepening the harbour, a few years since, the following fossils were met with :—

Ammonites cordatus.
Fragments of several other species.
Belemnites Oweni.
Perna mytiloides.
Homomya oblata.
Gresslya.
Thracia pinguis.
Nucula ornata.
Modiola bipartita.
„ *cuneata.*

* The low cliff of blue clay in Newton's Cove, though resembling Oxford clay and containing *Modiola bipartita*, an Oxford clay species, must, from its position, be considered a subordinate bed of the Oxford oolite.

OXFORD CLAY.—Jordan Cliff.

A valley of denudation has been formed through the Coral rag and Oxford clay between Preston Hill and Jordan Cliff.

The clay beds are here interspersed with thin stony layers. There is also a singular bed of serpulæ (*Vermilia sulcata*), some two or three inches in thickness, implying the existence of an undisturbed sea-bottom during a prolonged period.

Gryphœa dilatata is the most abundant fossil.

The upper part of the cliff contains numerous nacreous impressions of large ammonites, modiolæ, &c.

OXFORD CLAY.—Greenhill.

The following fossils have been collected here:—

Reptilia.

Vertebræ of *Plesiosaurus plani-spondylus*, Owen.
" *Ichthyosauri.*

Fishes.

Leptolepis.
Coprolites.

Cephalopoda.

Ammonites athletus, Phil.
" *Reginaldi.*
" *cymodoce.*
" *Gowerianus.*
" *Kœnigi.*
" *cordatus.*
" *vertebralis.*
Belemnites Oweni.
" *hastatus.*
" *gracilis.*

Mollusca.

Cerithium Damonis.

Gryphœa dilatata. Abundant.
„ (*Exogyra*) *virgula.*
Nucula ornata.
Pentacrinus Fisheri, Forbes.
Serpula vertebralis.
Vermilia sulcata.
Lignite.
Selenite. Crystals; abundant.
Septaria. Much flattened.

Half a-mile west of the Greenhill, and near to that part of the backwater marked in local maps 'Radipole barracks,'* the Oxford clay is cut through by the West Somerset and Weymouth Railway, and after an embankment of a quarter of a mile, a second open cutting occurs. Fossils are numerous in the first cutting, but much compressed. The bed is bituminous, and has the peculiar odour which characterises the inflammable shale of the Kimeridge strata, though of a less pungent nature. I have collected a great variety of fossils from this spot; but the slopes having since been turfed the Oxford clay is no longer visible.

Aptychus or *Trigonellites latus* of authors, occurs somewhat plentifully. See note on Ammonites in Appendix.

The best Oxford clay fossils of the district, and in the greatest variety have been procured from the bed of the backwater. The stratum referred to rises to about two feet from the surface in a direction from east to west, and is crossed by the railway embankment. The stratum dips rapidly to the south. It is here the septaria occur.

List of Fossils from the Oxford Clay, at Radipole Backwater.

Vertebrata.

Ichthyosaurus. Vertebræ and other bones.
Plesiosaurus plani-spondylus, ditto.

* The barracks referred to were removed many years since.

Cephalopoda.

Ammonites Gulielmi, Sow. In septarian nodules with brilliant iridescent colours.
„ *Kœnigi*, Sow.
„ *striolaris*, Quenstedt.
„ *modiolaris* (*A. sublævis*, Sow.)
„ *Gowerianus*, Sow.
„ *macrocephalus*, Schloth.
„ *Williamsoni*, Phil.
„ *vertumnus*, Leckenby.
„ *cordatus*, Sow.
„ *vertebralis*, Sow.
„ *Lamberti* (*A. Leachii—A. Mariæ*), Sow.
„ *Duncani*, Sow.
„ „ var. *spinosus*.
„ *crenatus*, Brug.
„ *Chauvinii*, D'Orb.
„ *perarmatus*, young, Sow.
„ *Reginaldi*, Morris.
„ *lenticularis*, Phil.
„ *cymodoce*, D'Orb.
„ *annularis*, Rein.
„ *longispinus*, Sow.
„ *Jason*, Rein.
„ *placenta*, Leckenby.
„ *hecticus*.
Aptychus (*Trigonelites latus* of authors.)
Nautilus hexagonus, Sow.
Belemnites Oweni, Pratt
„ Very large species.
„ *hastatus*, Blain.
„ *gracilis*, Phil.

Gasteropoda.

Cerithium Damonis, n. sp., Lycet.
Alaria (Rostellaria) *trifida*, Phil.
Patella.

CONCHIFERA.

Pholadomya paucicosta. Var. Ag.
Modiola bipartita, Sow.
,, *cuneata*, Sow.
Trigonia clavellata, Sow.
,, *elongata*, Sow.
Perna mytiloides, Goldf.
Hinnites.
Pecten fibrosus, Sow.
,, Small species undetermined.
Homomya oblata, Sow.
Gresslya (Unio) peregrina, Phil.
Thracia pinguis, Ag.
Cardium striatulum, Sow.
Nucula ornata, Quenstedt.
Avicula inæquivalvis, Sow.
Gryphæa dilatata, Sow.
,, *(Exogyra) virgula*, Defrance.
,, Small species.
Ostrea * *Marshii*, Sow.
Serpula vertebralis, Sow.
Vermilia sulcata, Sow.
Lignite.

On the west shore of the backwater, several species of small mineralised ammonites are to be found, together with *Gryphæa dilatata*, *Belemnites gracilis*, *Lignite*, and crystals of selenite, and the same fossils reappear in a similar manner in the low cliff of the Fleet, forming the western termination of the Oxford clay in this district, and indeed in Great Britain.

* A bed of this species is sometimes exposed at the north end of the backwater.

CORAL RAG (Coralline Oolite—Oxford Oolite) AND CALCAREOUS GRIT.

Characteristic Fossils. Plates of Fossils, Nos. 4, 5, and 8.

This formation is composed of alternating beds of coarse limestone, calcareous sands, occasional clay partings, and large concretional masses of grit. The upper and lower portions, between which the coralline (or as is the case here, the shelly) bed intervenes, are known as the upper and lower calcareous grits.* The entire thickness of the series at Weymouth is 250 feet.† At Linton Hill, near Abbotsbury, the Coral rag attains its greatest elevation.

Professor Sedgwick ('Annals of Philosophy' for the year 1826) published the following list of the successive beds of this formation occurring between Weymouth Harbour and the foot of Sandsfoot Castle.‡

No. 1. Beds near the Jetty, on Oxford clay, composed of a calcareous grit, harsh and meagre to the touch, with irregular stems branching out and intersecting each other in every direction.

No. 2. Thin beds of yellow sands and sandstone.

No. 3. Strong beds of calcareous grit like No. 1, but more ferruginous.

No. 4. Blue argillaceous beds alternating with hard compact beds.

---

* Pisolite of Smith. 'Strata identified.'

† The corresponding strata on the coast of Yorkshire are 200 feet thick, and thus divided:—

Upper calcareous grit . . .	60 feet
Coral rag, or middle portion . .	60 „
Lower calcareous grit . . .	80 „
	200 „

Phillips' 'Geo. Pro.,' vol. xiv. p. 84.

‡ These beds have been further subdivided in the 'Memoir of the Geology of Weymouth,' by Prof. Buckland and Sir H. De la Beche.

No. 5. Beds of yellow sand resembling No. 2; near the tops of calcareous grit with argillaceous partings in structure as Nos. 1 and 3.

No. 6. Beds of oolite with argillaceous partings alternating with other shelly oolitic beds, like forest marble.

No. 7. Thin beds of oolitic marble with *Clypeus clunicularis.*

No. 8. A group of impure sandy oolite with *Ostrea deltoidea* and other fossils.

No. 9. Sandy oolite with innumerable *Trigonia clavellata.*

No. 10. Kimeridge clay, with large beds of *Ostrea deltoidea.*

No. 11. Beds of ferruginous calcareous grit alternating with beds of red and green sand and blue clay with *Ostrea deltoidea.*

A line drawn from each end of the above section in a south-west direction, terminating at the Fleet backwater, forms the southern zone of the Coral rag, while from the coast at Osmington another but narrower belt extends to Abbotsbury on the west.

The *lower calcareous grit* commences at the base of the Nothe Cliff, where the passage from the Oxford clay is sharp and well defined. The *upper* graduates into the Kimeridge clay on the coast near Sandsfoot Castle: between the upper and lower calcareous grit the beds become more oolitic, and organic remains more numerous and better preserved.

This portion of the series has given rise to the name of the formation, owing to the large number of corals by which in some districts it is characterised.* In Weymouth the Coral rag yields but few corals. It is generally found that mollusca are rare where corals are numerous, and *vice versâ.*

* At Steeple Ashton, in Wiltshire, and Nattheim in Wurtemberg, I have found them to occur in the greatest profusion. The genus *Thecosmilia* prevails in both these districts. The *Thecosmilia annularis* (Plate 5, Fig. 12), Milne-Edw., found in the Coral rag, Weymouth, is the common species at Steeple Ashton.

Plate 9.

Fig. 24.

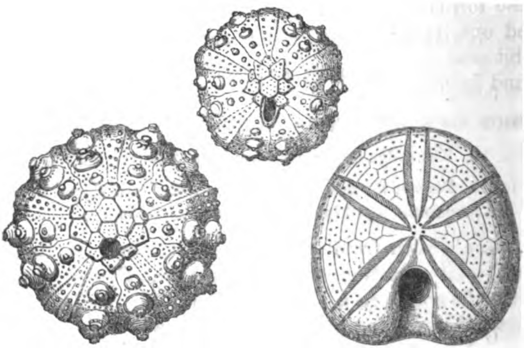


Fig. 25. Fig. 26.

24. *Acrosalenia decorata.*
25. *Hemicidaris intermedia.* The Calne cidaris.
26. *Nucleolites scutatus.*
All natural size. Coral Rag, Weymouth.

Echinidæ, or Sea Urchins, form an order of the class *Radiata*, so named from their parts being disposed round a common centre. They appear first in the carboniferous limestone, but sparingly: they are also distributed through the lias, but obtain their maximum development in the oolitic and cretaceous strata. They diminish in number in the tertiary, all the recorded species of which period belong to existing genera. The Echinidæ, though so numerous and largely developed throughout the Coral rag series, are nearly absent in the Kimeridge clay, the formation immediately above. The only exception in this district is that in the lower bed of the Kimeridge clay spines of *Cidaris florigemma*, Plate 6, Fig. 12 (Coral rag species) occur. This paucity of Echinidæ in the Kimeridge clay may arise from the clayey strata being less favourable to their preservation than are the calcareous and stony beds, as we neither have them abundantly distributed in the Oxford clay nor Kimeridge clay, though they are more or less plentiful in the beds adjacent to these formations. Though many of the fossil forms have died out, there are several still represented. They inhabit seas of various temperatures. Thirteen species are found living on the British coast.

Fossils from the Calcareous Grit of Nothe Point and the Cliffs towards Sandsfoot Castle.

Teleosaurus. Portions.
Ammonites cordatus.
Pleurotomaria reticulata.
Pecten vagans. Var. Abundant.
" " Species allied to P. vagans.
" *demissus.*
Goniomya literata.
Myacites decurtatus.
" *securiforme.*
Pholadomya æqualis.
Perna quadrata.
Ostrea solitaria.
Gryphæa dilatata.
" Small species.
Trigonia clavellata.

Fossils from the Coral Rag, *a Quarter of a Mile* North Side of Sandsfoot Castle.

Palatal teeth of *Pycnodus.* Fragments of dorsal spines of *Asteracanthus.*

Cephalapoda.

Ammonites cordatus.
" *perarmatus.*
Nautilus hexagonus.
Belemnites abbreviatus.

Note.—Imbedded organic remains are important records, as from these we learn the depth or shallowness of the sea, quality of the water, proximity of land and rivers, with many other contemporaneous conditions under which the strata were formed.

Gasteropoda.

Littorina muricata.
Natica silicea.
  ,, *clio.* Var.
  ,, *corallina.* N. sp.
Nerita. Species uncertain.
Alaria Composita.
*Nerinœa** *Goodhallii*, Sow.
Chemnitzia Heddingtonensis.
  ,, A small species in a seam of coarse sand.
Pleurotomaria reticulata.
  ,, (?)
Trochus (?)

Conchifera.

Trigonia monilifera. Ag.
  ,, *clavellata.* Abundant.
Astarte cuneata.
  ,, *aliena.*
Myacites decurtatus.
Opis corallina. N. sp.
Isocardia minima.
  ,, *inflata.*
Perna quadrata.
Pinna lanceolata. Abundant.
Goniomya (Mya) literata.
  ,, v. *scripta.*
Gervillia aviculoides.
Modiola (?)
Mytilus pectinatus.
Cucullœa corallina.
Ostrea solitaria.
  ,, Small species.
  ,, *duriuscula.*
Exogyra (?)
Inoceramus (?)

* A singular spiral shell, which when entire exceeds a foot in length. Plate 5, Fig. 8.

Pecten vagans. Var., frequently retaining the original colour of the shell.

„ *demissus.*

Hinnites abjectus.

Cardium striatulum

Lima rudis.

Lima pectiniformis.

Pholadomya æqualis.

ECHINODERMATA.

Nucleolites scutatus.

Cidaris florigemma.

Hemicidaris intermedia.

Acrosalenia decorata.

ANNELIDA.

Serpula intestinalis.

CORALS.

Thecosmilia annularis.

Thamnastrea arachnoides.

Alcyonium (?)

Lignite.

The singular appearance of the masses of grit on the shore near the old castle will attract attention. Their surfaces are traversed with some vegetable remains, spreading in all directions, forming a kind of network; which latter condition arises from the casts themselves, and the grit over which they spread, having decayed in an unequal degree. The Trigonia bed occurs here, but extends over a smaller area than on the north shore.

CALCAREOUS GRIT. (PRESTON HILL to HAM CLIFF.)

This portion of the Coral rag is very fully developed on this part of the coast. The immense blocks detached from the overlying cliffs, by reason of the thin sandy partings are, as on the Weymouth side, covered with fucoidal remains. We see, among the loose rocks, some with a furrowed rippled surface, formed by the tidal waters before the stone was consolidated, and answering to the ripple-marks and other conditions of an existing sandy shore. Numerous cracks that traverse the stony beds have their sides coated with a white stalagmite of carbonate of lime.

At *Ham Cliff* the Coral rag is let down, by a conspicuous fault to a level with the Oxford clay, as seen in the section Fig. 27. At Preston Hill the beds are horizontal, but here they have a considerable dip.

Fig. 27.

a. Chalk. *b*. Upper Greensand. *c*. Portland Stone. *d*. Portland Sand. *e*. Kimeridge Clay. *f*. Coral Rag. *g*. Oxford Clay.

Fossils from the Calcareous Grit of the Coral Rag, Preston Hill.

Ammonites perarmatus.
,, *Achilles*, D'Orb.
,, (?)
Pleurotomaria reticulata.
Chemnitzia Heddingtonensis.
Trigonia clavellata. Large variety.
Pholadomya paucicosta, Ag.
,,
Modiola (?)
Myacites securiforme. Large variety.
Gryphœa dilatata. Larger and of greater width relatively than the Oxford clay species.
Ostrea solitaria.
Pecten vagans. Var.
,,
Serpula.
Crypts of Lithomodus molluscs in G. dilatata.
Lignite.

Several of the above species, that are common to this and the adjacent beds, here attain their maximum size. Ex. *Trigonia clavellata*, *Pholadomya paucicostata*, *Myacites securiforme*, *Gryphæa dilatata*, all of which are much larger than the same species found in the Oxford clay, or Coral rag (middle bed).

Towards the top of the cliff over Radcliff Head a portion of the calcareous grit, highly oolitic, has disintegrated and formed a loose deposit like so much mustard-seed. On examining these particles under a strong magnifying glass, it will be observed that a great part of them consist of organized bodies belonging to the order Foraminifera.*

Coral Rag from the Shore at Osmington Mills to Ham Cliff.

The Kimeridge clay, which rises from the shore a little west of Osmington Mills, is succeeded by—

1. Grey-coloured marly stone (upper calcareous grit), non-oolitic, much broken in a vertical direction, and interspersed with clay partings of like colour. The stony beds contain numerous casts of *Pleurotomaria*, *Myacites*, *Pholadomya*, and other species common to the Coral rag.

2. Coarse ferruginous grit (containing *O. deltoidea*): that towards the middle portion is oolitic, the grains being red, and imparting a peculiar tinge to the fossils of this stratum. It is rich in organic remains, generally well preserved. By way of distinction I have denominated this the "red bed" of the coral rag.

3. Shelly bed of bluish-grey ragstone, very fossiliferous, highly charged with *Trigonia clavellata*, and corresponding

* Some of the Foraminifera have a great vertical range. Sir R. Murchison (Geology of Russia) states that the same species have been traced from the coal-measures through the succeeding strata to the present time. It is easy to understand how such minute bodies might survive a catastrophe that would prove destructive to larger animals, of which the more bulky rarely if ever escaped.

to the stratum in the lower cliff a quarter of a mile north of the Sandsfoot Castle already described.

4. Pea-grit. An aggregation of calcareo-siliceous rounded particles of irregular shape, mingled with oolitic grains, firmly held by a cementing matrix, of a bluish colour, without fossils. I have not observed this bed in any other locality.

5. Light-coloured clay, destitute of fossils.

6. Cream-coloured oolite, which at the village of Osmington close by, is quarried for building. It agrees with the bed forming the cliff at the back of Wyke church, having its characteristic fossil, Nucleolites scutatus, in abundance. A small *opis*, apparently of a new species, also occurs.

On the shore, a mile farther to the west, where this stratum rises to the surface tilted inland, the under side of some of the blocks are strewed with well-preserved shells—*Echinidæ*, *Annelids*, and *fucoidal* impressions.

List of the Fossils that may be observed in the position referred to. Several are not found in any of the adjacent beds, and some appear to be undescribed species :—

Nucleolites scutatus with spines.	*Cucullæa* or *arca*.
Nerinæa	*Modiola*
Alaria	*Trigonia clavellata*.
Cerithium	*Ostrea*
Buccimun	*Gryphea*
Natica, two species.	*Myacites*
Trochus	*Lima*
	Pecten

7. Grey-coloured grit with clay partings, agreeing with bed No. 1, followed by the Oxford clay.

The strata, throughout this locality, are very much out of position, being tilted at different angles and fractured so as to have produced several faults, which are marked by deep indentations in the cliff. Some of the beds dip beneath the surface and at a short distance reappear with a different degree of inclination.

List of Fossils from the Coral Rag between Osmington Mills and Ham Cliff: chiefly from beds numbered above 2 and 3.

Fishes.

Palatal teeth of *Pycnodus*.
Asteracanthus, portions of dorsal fin.

Crustacea.

Portions only.

Cephalopoda.

Nautilus hexagonus, Sow.
Ammonites Eupalus, D'Orb.
„ *cordatus*, Sow.
„ *perarmatus*, Sow.
„ *lenticularis*, Phil.
„ (?)
„ (?)
Belemnites abbreviatus, Miller.

Gasteropoda.

Pleurotomaria reticulata, Sow.
„ Allied to *Anglica*.
„ *Munsteri*, Rœm.
Trochus.
Littorina muricata, Sow.
Chemnitzia Heddingtonensis, Sow.
Phasianella, (*Melania*) *striata*, Sow.
Nerita. Species uncertain.
Natica silicea, Quenstedt.
„ *clio*, D'Orb, var.
„ *corallina*. N. sp.
Alaria (*Rostellaria*) *composita*, Sow.
„ *hamulus*, Desl.
Nerinœa Goodhallii, Sow.

Conchifera.

Trigonia monilifera, Ag.
,, *clavellata*, Sow. Abundant.
Astarte ovata, Phil.
,, *Thompsonii*. N. sp.
,, *modiolaris*, Lam. var.
,, *aliena*, Phil.
Cyprina.
Myacites decurtatus, Phil.
Opis corallina. N. sp.
Isocardia minima, Sow.
,, *inflata* (or var.), Voltz.
Perna quadrata, Phil., but not of Sowerby.
Pinna lanceolata, Sow.
Goniomya (*Mya*) *literata*, Goldf.
,, ,, v. *scripta*, Goldf.
Gervillia aviculoides, Sow.
Modiola (?)
Mytilus pectinatus, Sow.
,, (?)
Pholadomya æqualis, Sow.
Cucullæa corallina, Sow.
Plicatula tubifera, Lam.
Ostrea solitaria, Sow.
,, *gregaria*, Sow.
,, *Roemeri*, Quenstedt.
,, Small species, numerous.
,, *duriuscula*, Phil.
Exogyra, (?)
Inoceramus, (?)
Pecten arcuatus, Sow.
,, *annulatus*, Sow.
,, *vimineus*, Sow.
,, *vagans*, var., Sow.
,, *demissus*, Phil.
Hinnites abjectus.

Lima rigida, Sow.
„ *pectiniformis*, Schloth.
Cardium striatulum, Sow.

ECHINODERMATA.

Cidaris florigemma, Phil.
Nucleolites scutatus, Gmel.
(*Clypeus dimidiatus*, Phil.)
Pygurus pentagonalis, Phil.
Hemicidaris intermedia, Flem. sp.
Diadema.
Acrosalenia decorata, Forbes.

ANNELIDA.

Serpula intestinalis, Phil.
Vermilia sulcata, Sow.

CORALS.

Thamnastrea arachnoides, Parkinson.
Thecosmilia annularis, Flem, sp.

CORAL RAG.—(East of OSMINGTON MILLS.)

Most of the beds just enumerated, are repeated on the coast east of Osmington Mills, where the upper part of the series graduate into the Kimeridge clay at Ringstead Bay. See Fig. 14 for the order of succession.

A cascade passes over a bed of ferruginous grit, which is here of considerable thickness, and more homogenous in texture than in the last-named locality. Among the prevailing fossils are a large species of Nucleolites, casts of *Trigoniæ*, *Pholadomya*, &c. It is also much perforated with borings of Mollusca.

CORAL RAG.—BROADWEY.

Near the residence of John Moor Bridge, Esq., in the above parish, the Coral rag has been quarried for lime-burning. The stone, which is highly fossiliferous, occurs in beds, each about two feet in thickness, alternating with light brown-coloured stiff clays.

The following fossils may be collected here :—

Chemnitzia Heddingtonensis.
Nerinœa (?)
Nerita hemispherica, Roemer.
Natica, two species.
Pleurotomaria reticulata
Terebratula insignis, Quen.
Ceromya excentrica (*Isocardia excentrica*, Volt). New to Great Britain.
Pecten vagans, and two other species.
Ostrea deltoidea.
,, *duriuscula.*
,, *solitaria.*
,, (?)
Trigonia clavellata.
,, *monilifera.*
Myacites, two species.
Opis corallina.
Gervillia aviculoides.
Cucullœa corallina.
Pholadomya œqualis.
Isocardia minima.
Nucleolites scutatus.

CLIFFS WEST OF WYKE CHURCH.—This stratum of the coralline oolite differs from the other beds of the formation; being composed of a fossiliferous cream-coloured oolite, the grains composing which are larger and the stone more uniform in texture, but from the manner in which it has "weathered" it is obviously ill adapted for building purposes.* The same bed occurs at Osmington, and is there quarried. In a section of Coral rag on the coast, half-a-mile east of Osmington Mills, the stratum is, from its whiteness, very conspicuous. Organic remains are abundant but not very varied.

Nerinœa. (?)
Chemnitzia Heddingtonensis.
„ A small species.
Natica (?)
Cucullœa corallina.
Trigonia clavellata.
Myacites decurtatus.
Pecten vagans, var. (?)
Ostrea, a small species.
Nucleolites scutatus. Very abundant.

At Abbotsbury, the upper part of this formation contains oolitic grains of hydrous oxide of iron,† imbedded in a calcareous base, and forming an iron ore of which the following is an analysis by G. D. Livering, Esq., of St. John's College, Cambridge. A portion was taken at random, pounded up, and a part of the powder analysed, so as to give as near the average composition as possible—

	Per Cent.
Sesqui-oxide of iron	43,97
Silica	42,60
Magnesia	1,40
Lime	trace
Common Salt	do.
Water	11,88
	99,85

* Referring to this stone, Mr. Conybeare observes that Oxford has reason to regret its vicinity to this formation; for the stone has been used in many of the public structures, and after a few years exposure scaled off in large flanks.

† The presence of iron may be detected by placing a portion of the bruised ore in an iron spoon over the fire, when the particles of iron will separate and fall to the bottom. In smelting furnaces this process is hastened by the addition of limo and other substances.

This is equivalent to about 34 to 35 per cent of iron in the roasted ore. At Red Lane, a little beyond the village, it is of a deep rusty red colour, forming incoherent and heavy masses. About half a mile to the west, on the road to Gorwell, there are bands containing a larger proportion of metallic iron. In the former state it exists to a considerable extent, in the latter and more valuable form it is less abundant. Other parts of the Coral rag, in the neighbourhood of Weymouth, are more or less ferruginous, as may be seen in the rusty-looking cliff near Sandsfoot Castle, but nowhere is it so rich in iron as at Abbotsbury.* At some period these beds will doubtless be turned to account, either by the erection of furnaces on the spot, or, more probably, by the conveyance of the raw material to existing foundries elsewhere.†

The oolites of Yorkshire, Wilts, and other parts of England, contain similar deposits, all of which are below the Kimeridge clay. At Westbury, in the latter county, blast-furnaces for smelting the oolite ore found in the neighbourhood are erected adjoining the railway station, and have been in operation for some time. In Yorkshire the quantity annually raised is very considerable.‡ It is

* There is in the Fleet stream at Abbotsbury a decoy pond and swanery, the property of the Earl of Ilchester, whose castle and gardens are situated a little out of the village. Besides these attractions there is an ancient chapel, dedicated to St. Catherine, and the remains of a monastery; hence this village is much frequented during the summer. Distance from Weymouth, 9 miles.

† The late Earl of Ilchester was well aware of the mineral value of this formation; and, I am told, rather regretted its existence than otherwise. He was much attached to the wild scenery and solitude of this part of his estate, and would not give encouragement to any project that would tend to divest it of these attractions.

‡ 'The iron stone of Yorkshire (from the middle lias) supplies long ranges of blast furnaces on the Tees, and sends half a million of tons of ore to the great iron works west of Durham. This vast supply will soon be doubled or trebled, the material being inexhaustible.' Phillips' 'Geo. Pro.,' vol. xiv. p. 84.

[NOTE

only of late years that the iron ore of the oolites has been so extensively used.

Fossils from the Coral Rag found at Red Lane and Gorwell Road, Abbotsbury.

Ammonites (?)
Pleurotomaria reticulata.
Natica (?)
Nerita (?)
Nerinæa (?)
Chemnitzia Heddingtonensis.
Ostrea (?)
Myacites decurtatus.
Terebratula insignis, Davidson.
,, *ornithocephala*, Sow.
Rhynchonella farcta, Lin. sp.
Nucleolites scutatus.

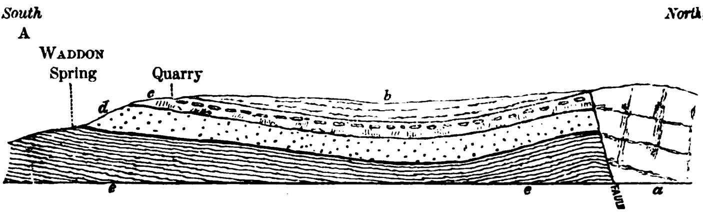
Luton Hill, one mile east of Abbotsbury.—An escarpment of Coral rag here attains its greatest elevation, being at a considerably higher level than the beds at Gorwell-road, though belonging to a lower part of the series. It contains a less amount of iron, but fossils are more numerous and better preserved here than in the latter locality. They include—

Note.—In passing over the Belgian railway from Charleroi to Namur I was struck with the number of blast furnaces which for several miles raise their tall chimneys on both sides of the line, exhibiting an amount of manufacturing industry apparently equal to that of the iron districts of our own country.

On examining the ore which supplied these extensive establishments, I found it to be of the same kind, and not distinguishable from that which exists at Abbotsbury. Throughout France the foundries appear to be supplied chiefly with an oolitic ore. In the neighbourhood of Boulogne it is worked to a great extent, supplying furnaces at Mirquise, a few miles from that town, which employ 4000 men. The same description of ore is used in furnaces at Forbach, Chalons, Metz, &c.

Nerinœa
Chemnitzia Heddingtonensis.
Pleurotomaria reticulata.
Natica.
Myacites decurtatus.
Goniomya v. scripta.
Terebratula.
Nucleolites scutatus.

Fig. 28.

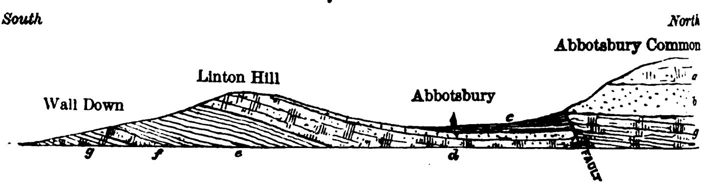


a. Chalk. *b.* Purbeck Beds. *c.* Portland Stone. *d.* Portland Sand. *e.* Kimeridge Clay.

From a section by Mr. Bristow in the published sections of the Geological Survey of Great Britain.

Fig. 29.

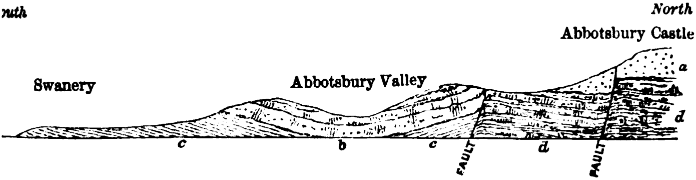
Section from Abbotsbury Common to the West Fleet.



a. Chalk. *b.* Upper Greensand. *c.* Kimeridge Clay. *d.* Coral Rag. *e.* Oxford Clay. *f.* Cornbrash. *g.* Forest Marble.

Fig. 30.

Section from Abbotsbury Castle to the Swanery.



a. Upper Greensand. *b.* Coral Rag. *c.* Oxford Clay. *d.* Forest Marble.

The three Figs. 28, 29, 30, are introduced to show the effects produced by the great Ridgeway fault in the course of its western extension. Of these Fig. 28 is copied from one of the longitudinal sections of the Geological Survey by Mr. Bristow, and represents the trough-shaped position of the strata on the south side of the fault, about half a mile east of where the Purbeck beds finally terminate at Portisham. The Portland stone is here brought up into immediate contact with the Chalk, which dips in a southerly direction, turning up again (as shown in the figure) with a gentle dip in the opposite direction so as to form a synclinal curve. Hence on the southern escarpment the Portland stone and the Portland sand make their appearance, dipping towards the fault, and resting on the Kimeridge clay, which throws out a spring near its junction with the overlying sand. The Portland stone occupies only a very narrow breadth where it is crossed by the line of section, and gradually disappears at the surface altogether, the effect of the fault being to bring the overlying Purbeck strata into immediate contact with the chalk for the remaining distance occupied by that formation in a westerly direction.

Fig. 29 represents the derangements in the strata produced by the fault between Portisham and Abbotsbury. In this interval the Chalk and Upper Greensand occupy the north side of the fault, and the lower part of the latter is brought into juxtaposition with the Kimeridge clay which abuts upon the fault on the south side. The Upper Greensand is here based upon clays belonging to the Forest marble series, which make their appearance further west, occupying an acute triangular area between two faults, as is represented on the map of the Geological Survey and in the section Fig. 30 which follows. The synclinal or trough-like position of the strata on the south side of the fault is still maintained, while the hard calcareous beds of the Coral rag form the coast, and the southern escarpment of Linton Hill, dipping toward the north, and passing beneath the Kimeridge clay, which occupies the lower ground and extends to the line of fault. It must be mentioned here, however, that on approaching the fault the beds form a synclinal, and curve upwards towards the fault, from which they dip in a southerly direction to a greater degree and in a more marked manner than is represented in the diagram. The Chalk and the underlying beds north of the fault dip away from it at a small angle in the same direction.

Fig. 30 is a section of the strata taken on a line from the Swanery to Abbotsbury Castle. Although the synclinal position of the beds on the north side of the fault is still preserved, it will be observed that the Forest marble and Cornbrash which made their appearance in the last figure are not seen here; but that the Oxford clay is the lowest formation visible, while the Kimeridge clay has also disappeared, and the Coral rag is brought against the fault with a southerly dip. The great Ridgeway fault appears to have branched off here, and to have divided into two minor dislocations, the effect of which is shown on the maps of the Geological Survey. The effect of the disturbance has been to bring up the clays of the Forest marble, here overlaid by Greensand, and to place them in contact with the Coral rag on the south. The second fault on the north traverses the Upper Greensand, letting the beds on the south down, and producing that false escarpment and broken under-terrace facing the true escarpment of the lofty ridge of Greensand and Chalk composing Abbotsbury Common, alluded to by Sir H. De la

Beche and Dr. Buckland in their 'Memoir on the Geology of the Neighbourhood of Weymouth." To this cause also are due the landslips and the confused heaps of rubbish which have fallen from the higher ground, in some places appearing like immense steps on the southern escarpments of the hill.

KIMERIDGE CLAY (Oak-tree Clay of Smith).

Fig. 31.

Characteristic Fossil.

Ostrea deltoidea (flat oyster.) Kimeridge Clay, Weymouth.

This formation, which takes its name from a village on the coast east of Weymouth, occupies an important position in the geology of Weymouth, where its thickness has been estimated by Dr. Buckland, in his order of superposition of strata, as 600 feet. The Rev. Osmond Fisher assigns to the Kimeridge clay at Osmington a thickness of 530 feet.*

* Dr. Fitton gives only 300 feet to the Kimeridge clay, and he thus arrives at his conclusion: 'The coast at Kimeridge is not less than 400 feet below the bottom of the Portland stone, and if 100 feet of that interval be assigned to the Portland sand, it will follow that about 300 feet of the Kimeridge clay are disclosed on that coast, which probably is about the thickness of this formation.'—Dr. Fitton on the Strata below the Chalk, Geo. Trans., vol. iv. p. 213.

From the coast of Dorsetshire the Kimeridge clay extends inland, with little interruption, to the coast of Norfolk. It reappears on the opposite parts of the coast of France, in the Jura district, where it is dissimilar in mineral character, but is recognisable by its position and organic remains; in Medjansk, in Russia, where it offers the same shaly character as in Britain, and it becomes so bituminous as to have been mistaken for a coal-measure formation.

The bituminous and inflammable nature of a portion of the Kimeridge clay, coupled with its use as a substitute for fuel at Kimeridge and the adjacent villages, has obtained for it the name of Kimeridge coal.*

When coals bore a high price, this stratum was regularly worked, and sold at 9*d.* per hogshead, or 6*s.* a ton.† Its bituminous nature may be derived from either animal or vegetable sources, both being ascertained to be present. Though tough when first quarried, it splits into thin laminæ after exposure to the atmosphere, and burns with a crackling noise and the evolution of a considerable amount of sulphureous vapours, at the same time giving out much heat. From this bituminous schist‡ in Holworth Cliff, Ringstead Bay, spontaneous combustion proceeded in the autumn of 1826, and continued for some years. Sulphuretted hydrogen was liberated, the odour of which could be detected for several miles under certain circumstances.

This phenomenon first made its appearance immediately after a spring-tide, which, being attended with strong southerly gales, the waves broke over the cliff, and the water producing a decomposition of the iron pyrites in the shale was supposed to have been the cause of ignition.

* In chambers within the barrows of the Isle of Purbeck quantities of the shale have been found reduced to ashes.

† 'Gentleman's Magazine,' vol. xxxviii. year 1768.

‡ *Schiste* or *Bituminous Schistus*, the term applied on the Continent to this stratum.

§ When the sulphur and iron filings (iron and sulphur being the components of iron pyrites) are mixed in large quantities and made

If we remember rightly, there had previously been a slip in the cliff, by means of which a fresh portion of it had become exposed. Whatever might have been the exciting cause, certain it is that when once ignited it received increased force from heavy rains or sea-water. The cliff continued in a burning state several years, during which period it formed an object of considerable interest. On acquiring fresh energy, it threw out volumes of dense and suffocating smoke which, from its specific gravity, seldom rose high into the air. This was followed by bluish flames rising at times so far above the cliff as to be visible from Weymouth. Through the cracks spread over the surface by the ascending heat the burning stratum beneath was seen. The fissures and other openings were covered with deposits of sulphur. Some persons expressed alarm at residing so near a supposed volcano, but we need scarcely say it was unattended with explosive noises, eruptions, and the other phenomena ordinarily accompanying volcanic action. The combustion only ceased when the inflammable portion of the shale was consumed.* During the distillation

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into a paste with water they gradually become so hot that ignition ensues. 'Brande's Chemistry.'

Mr. Cross, the late eminent electrician and chemist, informed me that in the course of his experiments he had found spontaneous combustion to ensue from pulverised limestone and iron pyrites mixed in clay and buried for a year or two.

* Sir John Richardson says, in his 'Narrative of the Arctic Searching Expedition,' vol. i. p. 271, 'At Cape Bathurst, lat. 75 N., bituminous shale is exposed in many places, and in my visit there in 1826 was in a state of ignition; and the clays which had been thus exposed to the heat were baked and vitrified, so that the spot resembled an old brick-field.'

A similar ignition is recorded as having occurred in the lias forming the cliffs at Charmouth. 'There is in the lias cliff of Charmouth a good deal of pyrites, which took fire after a heavy rain, and produced an appearance of flame at a distance.' This happened in the year 1751, and a second followed in the year 1755. 'Chemical Essays,' by Bishop Watson. Maton's 'Observations on the Western Counties.'

of the shale, a process hereafter to be explained, sulphuretted hydrogen gas is evolved possessing considerable illuminating power.* With such an amount of the raw material as exists in the neighbourhood, a permanent supply of gas might be procured sufficient for the lighting of Weymouth; and if, by some inexpensive process, it could be cleansed from the sulphur and other impurities, which render it not only highly offensive to the smell but destructive to retorts, it might be thus applied. Besides the Kimeridge clay, there are interspersed throughout the oolite beds of shale and lignite sufficiently inflammable to form an imperfect kind of coal, which in many places is used as a substitute for that mineral.† Their occurrence having been regarded as an evidence of the proximity of real coal, many fruitless and costly attempts to obtain this shale have been made in districts where coal could only exist either at an unapproachable

* It is from beds of bituminous shale like that of Kimeridge that under certain circumstances spontaneous inflammable gas is emitted. Capt. Beaufort describes one of these natural jets near the Deliktosh coast of Karamania. Similar gases are evolved at Taman, Kertch, and Tiflis. Dr. Albich, who has explored the district, states that sulphur and iron pyrites are among the products. In the Chinese frontier of Tsetchuan such a gas has been economically applied for more than 1000 years. Bamboo pipes convey the gas from its source to the place where it is to be consumed. A single source of gas heats more than 300 kettles employed in evaporating saline water. Other bamboos conduct the gas intended for lighting the streets. See 'Edin. Phil. Journal.'

Referring to the inflammable shale of the Kimeridge clay, Dr. Mills, a late Dean of Exeter, says, it is not unlike the bitumen of the Dead Sea, and that the smoke arising from it resembles that of the latter. —'Phil. Trans.' vol. lxi. Dr. Pocock, 'Travels to the East,' vol. ii. p. 30, bears similar testimony.

† In Sutherlandshire a stratum 3 feet to 4 feet in thickness, known as the Brora coal, extends over a large area. The brown coal of Nassau is a similar formation, consisting chiefly of trunks of trees. These with other similar deposits may be in a state of transition to coal in its more perfect state.

depth* or at depths too great to allow of its being worked with success at the present day.

The products arising from the treatment and distillation of the shale, as set forth by a company† formed in Weymouth a few years since, for the purpose of working it, are—

First. A volatile oil or spirit, perfectly colourless, and transparent, chemically pure, and admirably adapted for lamps, and all other purposes for which naphtha or camphine is applicable, and on account of its purity, has great advantage over other oils, gas, &c., as it will not tarnish the polish of metals, or spoil the colour of fabrics.

Secondly. A denser oil, having no tendency to become rancid, and capable of burning pure in ordinary oil lamps, or for use in manufactories, lighthouses, &c. This second oil will also dissolve in any proportion with seed or fish-oils, augmenting considerably the illuminating power, and the time of burning, and prevents other oils from so soon becoming rancid and congealing by cold.

Thirdly. A fatty mineral oil, containing parafine or spermaceti in large quantities, and particularly applicable for lubricating machinery, and has the advantage over other oils in preserving all its unctuosity whilst in contact with metals, and being incapable of becoming siccative or dry.

Fourthly. A mineral tar of a jet black, and capable of being used for all purposes of varnish, and preserving wood and metal.

Fifthly, and lastly. The carbonaceous residuum, after the extraction of the above products, forms a manure of the richest quality, and also a powerful disinfectant; to this manure is added the ammo-

* Such trials have been made by sinking into this stratum at Sunning Hill, near Oxford, and at Farringdon in Berkshire. At Whiting's farm, near Shaftesbury they sank by subscription upwards of 100 feet.—'Geological Notes.'

† This company was afterwards reconstructed, and new works on a more extended scale were erected at Wareham, and which are now in operation. A similar stratum had been previously worked in France, at Autun, in the department of the Saone-et-Loire. Kimeridge, Ringstead, and Portland are the parts of the coast which in Dorsetshire yield it in the greatest abundance; and, so far as the object in view is concerned, the supply may be said to be inexhaustible.

nia coming from the distillation of the schist, and all the alkaline grease (rich in azote and caustic alkali), remaining after the treatment of the oils.

Produce of the distillation, and treatment of fifteen tons of bituminous schist :—

93 gallons, No. 1, volatile oil in spirit.
42 gallons, No. 2, fixed oil.
28 gallons, No. 3, fat oil.
5½ cwt., mineral pitch.
10¾ tons of carbon-treated manure.
7 cwt. ditto of pitch, second treatment.

Alum works formerly existed at Kimeridge. Alumina being the base of pure clay, it is found in all beds of shale.*

From the following notice of these early chemical works it appears that besides alum, other products were also obtained, and the bituminous shale was employed as fuel. 'The next place that offereth itself is *Smedmore*, where Sir William Clavile, descended of antiente gentrie, built a new house and beautified it with pleasant gardens. This place not long sithence had lordes of the same name, from whom it passed hereditarilie to the *Claviles*, neare adjoeining to the sea; and not farre hence, the nowe owner beeing ingenious in diverse faculties, put in tryall the makeing of allom, which hee had noe sooner, by much cost and travell, brought to a reasonable perfection, but the farmers of the allom workes seized to the king's use; and being not soe skillful or fortunate as himselfe, were forced with losses to leave it offe, and soe now it rests allmost ruined. * * * * * * But in place of it *Sir William*

* The alum-shale of the lias at Whitby is said to yield it in the largest proportion. The process is effected by means of roasting and lixiviation. When the iron pyrites of the clay is decomposed sulphuric acid is produced, which, combining with the aluminous earth, forms sulphate of iron and alumina. This being purified by subsequent processes, the alum of commerce is formed. 130 tons of the Whitby shale produce one ton of alum. There are no data to show in what proportion the Kimeridge shale yielded this substance.

Clavile, who one disaster dismayed not, hath sithence sett up a glasse house (which is come to perfection, and is likelie to redounde to a good benefit,) and salt-house. For transportation of these commodities, as alsoe of white salt, (there is made in great abundance, by boyling it out of the sea water,) hee hath at his owne charge, with great rocks and stones piled together, a little key, &c., &c.' 'They use a kinde of blueish stone that serve to burne, for maintaineing fire in the glass house ; but in burning yields such an offensive savour and extraordinaire blacknesse, that the people labouring about those fires are more like furies than men.'*

* 'Coker's Particular Survey of the County of Dorset.'

'20 Elizabeth grants the wood and lands of the Isle of Purbeck except allum and cheyne silver to John Englebey for 21 years.'—Hutchins' 'Hist. of Dorset.'

'All the allum houses and mines in the Isle of Purbeck were granted to Paul Pindar for 12 years.'—*Ibid.*

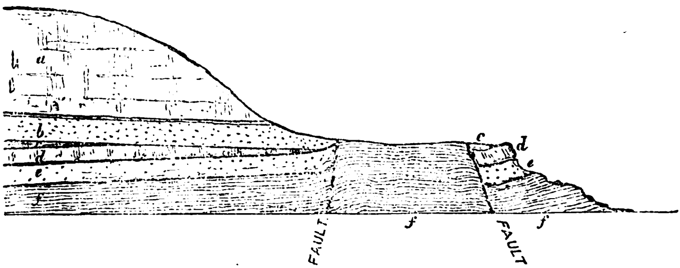
NOTE. *Coal Money.*—To the antiquary the Kimeridge shale is not without interest, as from it were made those curious and ancient relics known as coal money, which are found buried in the Isle of Purbeck. These are of circular shape, two to three inches in diameter, half an inch thick, flat on one side, on the other slightly concave, and moulded around the edge with from one to five holes near the rim, which, however, do not pass through the piece. They bear the appearance of having been turned in the lathe, and are generally found in quantity carefully placed a few feet below the surface, sometimes in urns, and very frequently in barrows associated with sacrificial and interred remains. At what period these relics, which have never been found in any other part of Great Britain, were produced is uncertain, but they are evidently the work of a very ancient people. Sir C. Hoare, who has written on the subject, ascribes their production to a colony who inhabited the site, neither Roman or British, but before both. ('Description of the Deveril Barrow.' Nicholls & Co., London, 1826.) The same obscurity exists as to their use, some supposing that they were simply tallies or the representatives of money, some that they formed an ancient sort of token money, while others again suppose that they were of some mystical use in sacrificial offerings or sepulchral rites. Besides these small circular pieces, large slabs of shale have been discovered, on which were traced circles and various other mathematical figures.

[In

The ruins of buildings and heaps of ashes were in the year 1748, the only remains left of the above-mentioned works.

Fig. 32.

Section of the Strata at Ringstead Bay.



a. Chalk. *b.* Upper Greensand. *c.* Purbeck Beds. *d.* Portland Stone. *e.* Portland Sand. *f.* Kimeridge Clay.

Fig. 32 is a representation of the effects produced by the overlapping action of the Upper Greensand, and by the faults which have produced dislocations in the strata at Ringstead Bay. The Upper Greensand in that locality rapidly stretches over the edges of the underlying strata, in consequence of its unconformability to them, as is apparent from an inspection of the geological map, in which the Upper Greensand is represented between Osmington

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In the Celtic barrows near Weymouth armlets made from the shale are not uncommon. In the Roman Villa at Preston, adjacent to the Roman Temple at Jordan Hill, portions of a chequered pavement formed of black and white tesseræ were found, the former being apparently derived from the Kimeridge shale, the latter from the limestone of the neighbourhood.

The Dorchester County Museum contains a great variety of the coal money from the Isle of Purbeck. This museum is also rich in early British and Roman remains found in the county of Dorset, including coins, bronze articles, celts, pottery, &c., amongst which there are some very choice specimens.

and Boat Cove, as overlapping the strata from the Weald clay and Hastings' sand formation to the Kimeridge clay inclusive, in the short distance of a quarter of a mile. The section represented in Fig. 32, is taken in the direction of the dip from the sea shore towards South Holworth. The fault nearest to the sea is a downfall towards the south, bringing the Purbeck beds *c* on the south side on a level with the Kimeridge clay *f* on the north, at the same time tilting the strata so let down in the direction of the fault at an angle of 30°. The northernmost fault on the other hand is a downthrow on the north side, bringing the base of the Upper Greensand on a level with the Kimeridge clay on the south side of the fault. Hence the combined effect of the two faults is to produce an elevation or upthrow of a lower formation (the Kimeridge clay,) between higher geological formations on either side of it. This locality derives an additional interest, apart from the geological pheonomena which it exhibits, in having been the site of the pseudo-volcano of which a description has been given at page 53.

The site of the pseudo-volcano generally presents a state of ruin, from the frequent land-slips and masses of stone detached from the overlying Portland beds; but the baked shale, converted into a condition resembling the fragments of overburnt bricks, is still visible. On the shore, near the Portland ferry-bridge, Dr. Buckland remembers to have seen, several years ago, a portion of the Kimeridge shale, which is now covered up with sand, and which at that time presented the appearance of slate burnt to the condition of red tiles; with the phenomenon that has since been exhibited in the same stratum of Kimeridge clay, at Ringstead, he was strongly of opinion that such combustion may have there taken place. (Geo. Trans. vol. iv., page 23.) Proceeding westward, the Kimeridge beds merge into the grit of the Coral rag, and no longer retain their oily and bituminous character, and peculiar odour, but pass into a coarse sandy state. This appears to be no uncommon condition of the lower part of the Kimeridge clay which graduates insensibly into the Coral rag beneath, as it does into the Portland sands above.* This bed may be denominated as the Lower Kimeridge grit, it being so dissimilar to the other parts of this formation. Several of the fossils found here do not occur in the beds above.

At Kimeridge, where the shale for the chemical works at Wareham is quarried, several rare fossils have been found.

Pliosaurus brachydeirus (Owen), a unique and magnificent example of the fore paddle of which, measuring 6 ft. 9 in. in length, was found a few years since, and presented by the lord of the manor, John Clavel Mansel, Esq., to the Dorset County Museum at Dorchester. In March, 1860, the same gentleman discovered the head of an animal of the same genus and of similar proportions to the paddle; the head being of the following enormous dimensions: 7 ft. 6 in. long, by 1 ft. 10 in. in breadth, being probably the head of one of the largest saurians that has yet been found. In addition to the above and other saurian remains from the same locality, Mr. Mansel has, with the exception of the head, an entire specimen of the Pliosaurus.

Of fish Sir Philip Egerton has recognised the following:

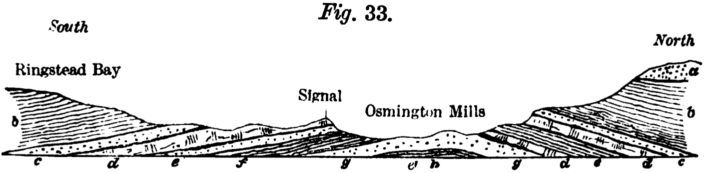
Pholidophorus, allied to the pholidophorus of Solenhofen.
Semionotus.

* This answers to the Kimeridge on the coast of France near Boulogne, where, on the left of the harbour towards the Fort of Caeche, this formation assumes this gritty condition described above as characterizing its passage into the subjacent Coral rag at Ringstead. The argillaceous portion of the Kimeridge series is there absent, and the entire formation consists of these beds of grit, capped by Portland stone, the Portland sand being either absent or obscure in its character. The fossils, which are in the greatest profusion, differ in species from those of this coast. I observed, as the most numerous in the fallen masses on the shore, *Gervillia aviculoides*, *Lima pectiniformis* (both Coral rag species), *Trigonia* (?) *elongata*, *Trigonia*, *Gryphæa*, *Unicardium*, *Perna*, *Ostrea deltoidea*, &c. The surface is traversed with fucoidal markings similar to those on the blocks of grit lying on the shore near Sandsfoot at Weymouth.

Pachycormus.
Thrissops.
Dorsal fin of *Asteracanthus ornatissimus.*
Coccoteuthis latipinnis (Owen). A new species of a large sepia, which Professor Owen supposes exceeded a yard in length (Described in Geo. Pro. vol. ii., page 123). Only two specimens of it are known; one of which is in the British Museum, the other in the cabinet of Mr. Groves of Wareham.
Belemnoteuthis.
Ammonites biplex.
" Species with closely set ribs.
" A small species.
Aptychus latus.
Gryphæa virgula.
Thracia concinna. N. sp.
Trigonia. Clavellated species.

KIMERIDGE CLAY.—Ringstead Bay.

Fig. 33.



a. Upper Greensand. *b.* Kimeridge Clay. *c.* Upper Grit. *d.* Oolite. *e.* Clay. *e'.* Grit. *f.* Grey Marl. *g.* Lower Grit. *h.* Kimeridge Clay.

The fine section presented by the cliffs of Ringstead Bay is by far the most favourable point for examining the beds of this formation, where they may be traced from the Portland stone and sands above to their junction with the Coral rag beneath. The following is an outline of the strata in their descending order :—

Portland beds.
Light-coloured fossiliferous sandy stone, about two feet thick, containing fishes' teeth and scales.

Succession of beds of dark clays, inflammable shale impregnated with sulphur, and containing iron pyrites. On exposure, it splits readily into thin laminæ, the surfaces of which are crowded with compressed shells, of which the most numerous are a clavellated species of Trigonia and a large species of Ammonite, with close-set ribs and two rows of tubercles. The nacreous portion of the Ammonites is preserved in brilliant iridescent colours. In one of the septarian nodules, which are numerous, the Rev. P. B. Brodie discovered portions of a small beetle.

Lower beds, which may be traced along the base of the cliff westward, becoming, as they approach the Coral rag, of a more sandy or gritty character. The fossils also differ, the prevailing kinds being *Lima pectiniformis*, *Ostrea deltoidea*, with numerous fish, coprolites, and casts of shells, for which see list of fossils from west side of Ringstead Bay, at page 64.

List of Fossils found in the middle portion of the Kimeridge series on the east side of Ringstead Bay.*

Pliosaurus. Vertebræ and other bones.
Fishes. Scales. Teeth. Coprolites.
Insect remains in septarian nodules.
Cidaris Blumenbachii. Spines only.
Ammonites triplicatus.
,, *biplex.*
,, *anceps.*
Alaria. (?)
Turbo. Cerithium and other small univalves much compressed.
Patella latissima, Sow.
Trigonia. A clavellated and undescribed species (abundant).

* This is one of the few known habitats for *Pamphila acteon*, or Lulworth skipper, a rare insect of the genus Pamphila, one of the diurnal Lepidoptera. It makes its appearance during the month of August. It has a short life of about ten days.

Astarte lineata.
,, A small species.
Thracia depressa.
Exogyra nana.
Ostrea deltoidea.
,, *virgula.*
Ligula ovalis.
Corbula.
Leda.
Cardium.
Venus.
Pinna.
Pecten.
Modiola

And a variety of other bivalves difficult to identify.

Serpula intestinalis.
Lignite.
Septaria, used for making cement.
Iron pyrites.
Crystals of Selenite.

FOSSILS from the LOWER KIMERIDGE CLAY, or KIMERIDGE GRIT, on the western side of Ringstead Bay. Several of these, it will be perceived, are Coral rag species, and disappear towards the middle and upper parts of the Kimeridge clay, while others are peculiar to this particular bed.

FISHES.

Teeth. *Scales.* *Coprolites.*
Dorsal spine of *Asteracanthus ornatissimus*, Ag.

CEPHALOPODA.

Ammonites biplex, Sow.
,, *rotundus*, Sow.
,, *anceps*, Reir.
, *triplicatus*, Sow.
,, *plicomphalus*, Sow.
, *canaliculatus*, D'Orb.
Belemnites Blainvillii, Voltz.

Gasteropoda.

Phasianella striata, Sow.
Chemnitzia Heddingtonensis, Sow.
Natica corallina. N. sp.
Pleurotomaria reticulata, Sow. Numerous.
„ Allied to *anglica*
Turbo (?)
Littorina muricata, Sow.
Alaria (?)
Eulima (?)

Conchifera.

Ostrea deltoidea, Sow. Abundant.
„ *gregaria*, Sow.
„ *læviuscula*, Sow.
Trigonia marginata. N. sp.
Modiola compressa, Goldf.
„
Pinna granulata, Sow.
Lima pectiniformis, Scloth. Numerous.
**Rhynchonella inconstans*, Sow. Ditto.
Isocardia minima, Sow.
Myacites recurvum, Phil.
„
Goniomya (*Mya*) *anguliferia*, Sow.
Phaladomya æqualis, Sow.
„ *angustata*, Sow.
„ *paucicosta*, Ag.
Cucullæa (?)
„

* In the proportion of about one-third the whorl is differently disposed. This species was formerly included in the genus Terebratula, but is now separated from it. It is distinguished from that genus by its acute beak. There are two recent species, one of which, *Rhynchonella psittacea*, is common in the northern seas, and is recorded to have been found on the British coast.

Unicardium sulcatum, Leckenby.
Cardium substriatulum, D'Orb.
Pecten demissus, Phil.
Exogyra virgula, Defr.

ECHINODERMATA.

Spines of *Cidaris Blumenbachii*, Munst.

ANNELIDA.

Serpula intestinalis, Phil.
Vermicularia.
Lignite.

It will be noticed that the above list of Kimeridge clay fossils contains a good many recurrent species: thus, the common deltoid oyster, *O. deltoidea*, first appeared in the Coral rag, while the equally common *Gryphæa dilatata* of the Oxford clay, abounds in the calcareous grit of the Coral rag. *Chemnitzia Heddingtonensis*, *Pleurotomaria reticulata*, &c., prevail equally in the Coral rag and lower grit of the Kimeridge clay; while of the *Trigonia clavellata*, of which there may be said to be millions of examples in the Coral rag, not one individual appears to pass upwards into the upper bed. Some of the species, like *Pholadomya paucicosta* and *Lima pectiniformis*, have a greater vertical range. At the close of each epoch there appears to have been an extinction of species succeeded by a new creation, the only exceptions being a few species that survived to the formation above; but "there are no facts leading to the opinion that species which have once died out have ever been reproduced."*

The Kimeridge clay reappears on the shore a little west of Osmington Mills, where it is capped with the Greensand. It gradually rises to the west, conformable to the upper calcareous grit of the Coral rag. Some fine remains of the Pliosaurus have been found here. *Ostrea deltoidea*

* Lyell's 'Principles,' p. 190.

and *Serpula intestinalis* are numerous. Besides these, fish vertebræ and coprolites, *Pholadomya*, *Myacites*, *Modiola*, *Trigonia*, are present &c., all in the form of casts.

From the coast at Ringstead, this formation passes through Preston, Upway, and Portisham, to Abbotsbury, where the main mass terminates, the boundary line extending as far as the church, and turning thence nearly in a north and south direction towards the fault. At the west end of the village, a small oval-shaped outlier, about a quarter of a mile long, and of half that breadth, rests upon the upper ferruginous beds of the Coral rag, which have been already described as forming a rich deposit of iron in the immediate neighbourhood of the village in question.

Passing to another part of our district, the Kimeridge clay rests upon the Coral rag at Sandsfoot Castle, and thence extends westward to Portland ferry-bridge, from which point it turns to the south-west, and for a short distance forms the bank of the Little Sea that separates the Chesil bank from the mainland.

FOSSILS from the KIMERIDGE CLAY. SANDSFOOT CASTLE.

Ammonites cordatus.
,, (?)
Belemnites Blainvillii, Voltz. Abundant.
Chemnitzia Heddingtonensis.
Pholadomya pelagica, Ag.
Goniomya angulifera.
,, *v. scripta.*
Pinna lanceolata.
Pecten. (?)
Ostrea deltoidea. In masses.
Lima pectiniformis.
Serpula intestinalis.

Some of the above fossils are from the beds of greenish and bluish-coloured sandy clays. The coarse ferruginous blocks that lie strewed on the shore are singularly marked with fucoidal casts, and contain besides *Lima pectiniformis*, *Pinna lanceolata*, &c.

The lower Kimeridge deposits and upper Calcareous grit are so mingled, that the line of separation is most indistinct. At Portland, the Kimeridge clay having been raised with the superincumbent beds, it crops out in its natural position immediately beneath the Portland sand, extending on the east to Pensylvania Castle, and on the west side of the island to the Black Nore; though from the great accumulation of debris on the shore, it is but little exposed. It forms the substratum of the island as well as also the anchorage-ground of the Portland roadstead, and there are evidences of its existence beneath the Chesil bank, when a ground sea removing the shingle on the shore exposes the stratum of blue clay beneath. The wells for supplying fresh water to the convict and other establishments on the island are sunk into the Kimeridge clay, in connection with which we may observe that after a drought it sometimes happens that rain falls on the mainland before it does on the island. This is indicated by the rising of the water in the wells, showing that the main source of the springs is beyond the island.

Kimeridge Clay,* *Portland*. Though it exists to a large extent at the north end of the island, it is not much exposed, but when laid open, the following fossils are met with.

* The prevailing fossils of the Kimeridge clay at Oxford are, *Ammonites planula*, *Terebratula pungens*, *Ostrea deltoidea*, *Trigoniæ*; of the Kimeridge clay of Yorkshire, *Am. plicomphalus*; fragments of other *Ammonites*, *Belemnites lateralis*, *Ostrea deltoidea*.—Phil. Geo. Yorkshire.

In the museum of the Town College in Boulogne I observed from the Kimeridge clay of that coast—*Turtle* bones, vertebræ and teeth of *Pliosauri*, *Pleisiosauri*, *Ichthyosauri*, *Fishes' palatal teeth*, *Aptychi*, *Nerinæa*, *Lima pectiniformis*, *Trigoniæ*, &c.

The Kimeridge beds of the Jura are characterized by *Ostrea solitaria*, *Ceromya*, *Pleuromya*, *Pholadomya protei*, *Ph. truncata*, *Perna plana*, *Mya*, *Trigonia plicata*, *Am. planula*.—'Fraas on the Jura Formation,' Geo. Pro. vol. vii. p. 73.

Towards the base there are rich bands of bituminous shale, which a few years since was quarried for chemical treatment.

Vertebræ of *Pliosaurus*.
Ammonites biplex. Mineralized.
" A small species, do.
Goniomya angulifera.
Astarte lineata.
Thracia depressa. (*Mya depressa*, Sow).
Ostrea deltoidea.
Cidaris Blumenbachii. Spines.
Serpula intestinalis.

ISLAND OF PORTLAND.

THE strata now coming under consideration have reference to the Island of Portland, where the formation known as the Portland (or upper) Oolite is so fully developed.

The Isle of Portland may be fairly considered as the most interesting geological feature on this part of the coast. Dr. Fitton, in the memoir already quoted, says, "that few places, probably, in the world exhibit with such clearness, and in so small a space, phenomena of more extraordinary interest, or of greater importance to theory." In geographical extent the island is four miles in length, and in its widest part one and a half miles in width. On the north end it rises at the Vern to a height of 495 feet,* but slopes so rapidly in a southerly direction,† that the Bill or southern termination is but twenty feet above the level of the sea at low-water mark. The Portland beds on the east of Weymouth Bay, dip toward the sea in a similar manner. The strata forming the highest point correspond to those seen at the level of the sea at Durlestone Head.

The Portland beds which include the marine limestone and subjacent sand, are not a wide-spread formation. They occur in Wilts, Oxfordshire, and Buckinghamshire, but are absent from the oolitic series of the north of England. They are very fully represented on the French

* Extract from Drayton's 'Polyolbion:'—

'Where Portland from her top doth over-peere the maine,
Her rugged front empal'd on every part with rocks,
Tho' indigent of wood, yet fraught with wooly flocks:
Most famous for her folke, excelling with the sling,
Of anie other heere this land inhabiting,
That herewith they in warre offensivelie might wound,
If yet the use of shot, invention had not found.'

† The exact direction is towards a point 48° E. of South.—See Ordnance map.

coast near Boulogne, and according to Oscar Fraas, are nowhere repeated on the Continent,* though M. Elie de Beaumont considers he has recognised them in Burgundy,† and M. de Dufrenoy in the neighbournood of Angoulesme.‡ There is a singular uniformity in the elevation of the Portland beds in the districts named, as if the agency which raised the Isle of Portland, acted with a similar force over a larger area. Brill Hills, on the borders of Buckinghamshire and Oxfordshire, exhibit the greatest elevation attained by this formation, viz., 550 feet, the Portland beds being near the summit-level. At Shotover Hill, which is 560 feet above the sea, they are 50 feet below the surface.§ At the Ridgway, over the villages of Preston, Chalbury, and Bincombe, they attain an elevation of about 500 feet. The Isle of Portland at its highest point is 495 feet.||

The Portland strata are seldom horizontal. In the counties referred to they dip slightly to the south. In the Isle of Purbeck, where they form part of the highly inclined and contorted strata which constitute that district, (as may be seen in the cliffs east of Lulworth Cove, and throughout the whole range of high land to the westward, extending to Portisham) are elevated to an angle of 45° dipping to the north. At Portland they incline to the south. This inclination in opposite directions, forms a portion of the Weymouth Saddle.

* 'The north German "Jura" formations of the Langenberg, and the before-mentioned limestones of France and Switzerland, have been termed "Portland," and attempts have even been made to apply this name to the Swabian and Franconian calcareous beds; but this general use of the term is quite erroneous, for there exists not the least similarity either in a mineralogical or a paleontological point of view between the Portland stone of England and the so-called "Portland" of France, Germany, and Switzerland.' (Boulogne must be excepted, as the identity of the Portland is beyond all doubt.—Ed.) 'Geo. Pro.,' vol. vii. p. 74.

† 'Annales des Sciences Nat.,' vol. for 1829.

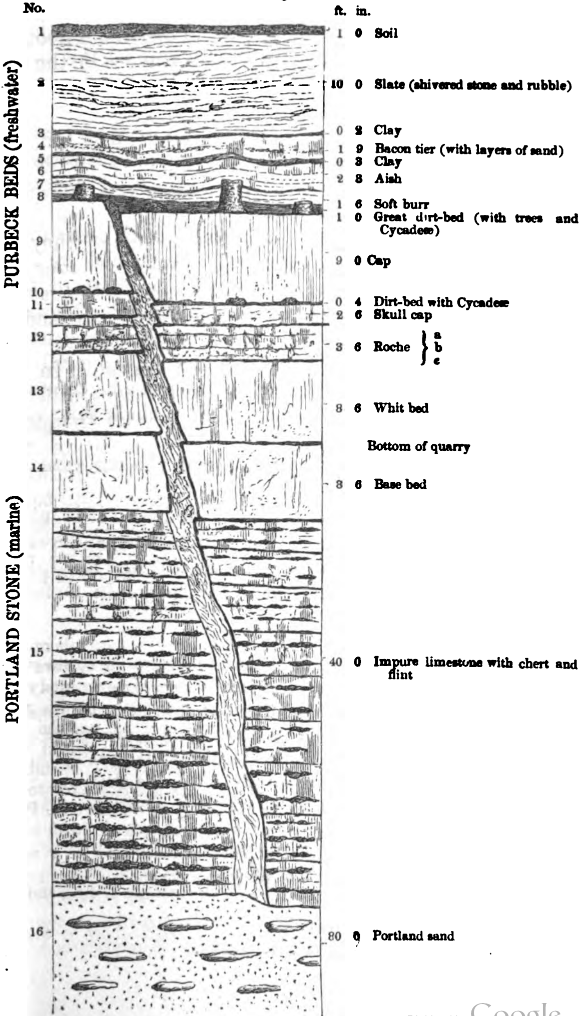
‡ 'Annales des Mines,' vol. ii. p. 434.

§ Conybeare and Phillips' 'Outlines of the Geology of England and Wales,' p. 183.

|| They have a similar elevation near Boulogne, as may be seen in the cliffs on the left hand entering the harbour.

Section of Fancy Quarry, Isle of Portland.

Fig. 34.



Bed 16.—PORTLAND SAND.

The Kimeridge clay is separated from the Portland stone by a stratum to which Dr. Fitton applied the name of "Portland sand." The latter is not to be confounded with those layers of loose sand which at Swindon alternate with the solid limestone forming an integral part of the Portland stone series, with which they are identical in composition, except as regards the absence of the calcareous or cementing ingredient.

The Portland sand is of a bluish-grey colour, containing grains of green earth (glauconite), ascertained by Dr. Turner to be of the same composition as those of the Greensand formation, which underlie the Chalk. Though originally deposited in the form of silt or sand, the sand of the Portland beds by pressure of the superincumbent strata* has become consolidated to its present compact state more resembling the texture of hard chalk than that of loose sand.

In some places it is more sandy, and the particles are less cohesive.

At Black Nore, on the west side of the island it is interspersed with sandstone and other concretions, and swells out to a thickness of 80 feet.† At St. Alban's Head, Dr. Fitton estimates it at 120 feet. At Thame, in Oxfordshire, it is 50 feet.‡

* The effects produced by superincumbent pressure on strata composed of loose materials has been illustrated by some experiments conducted by the late Mr. Brockedon. The best description of graphite having become scarce, he collected the dust formed in sawing the solid graphite into the oblong parallelopipeds required in the manufacture of drawing-pencils. After being repeatedly sifted, the dust was then placed under a powerful press and subjected to a succession of heavy blows, exercising a pressure equivalent to the weight of 1000 tons. The result was the production of a graphite, or black lead, in a solid form, and sufficiently coherent to break with a conchoidal fracture.—'Geo. Pro.' vol. ii. p. 31.

† Buckland and De la Beche, p. 20.

‡ 'Geol. Trans.' 2nd series, vol. iv. p. 320.

LIST of FOSSILS found at the BLACK NORE and CHESIL. In consequence of the shells being merely casts, there is frequently some difficulty in determining the precise species to which they belong :—

Ammonites giganteus, Young.
,, *triplex*.
Cardium dissimile.
Pecten lamellosus.
Trigonia incurva.
Thracia.
Myacites.
Ostrea.
Exogyra.
Serpula.

At Corton, a village two miles west of Upway, Portland sand fossils are abundant. The precise spot to be visited is a cutting near and on the north side of a farm and dairy-house.

Ammonites giganteus.
,, *triplex*.
Belemnites.
Pecten lamellosus.
Trigonia incurva.
Avicula.
Lima rustica, Sow.
Exogyra.
Ostrea.
Perna.
Cardium dissimile. Abundant.
Thracia.
Myacites.

BED 15.—This, the lowest of the solid beds of the Portland series, is (apart from its almost inaccessible depth) of little value for building purposes, owing to the quantity of chert and flint associated with it.

The situation in the island where this extensive formation can be most conveniently studied, is the new cutting on the N.E. side, where a fine section of 75 feet in vertical height is displayed for examination.

The following is an approximate thickness :—

Soil.
Rubble and cap, 20 feet.
Roach, 14 feet.
Impure stone with flinty masses, 35 to 40 feet.

The roach, though so remarkably persistent in other parts of the island, in the section here displayed swells out to much more than its usual thickness, and presents striking differences.*

The common "screw," *Cerithium Portlandicum*, so characteristic of the roach, is almost entirely absent, while on the other hand *Perna mytiloides*, which is rarely found in any of the quarries, is most numerous. So great a variaation in organic remains within a distance of a few hundred yards is remarkable, and implies a corresponding difference in depth of sea or other conditions during the deposition of the strata in question. The beds below consist of limestone, interspersed with flint, occasionally occurring in layers, but more frequently in nodules or patches.† The whole series is much shattered, and yields no good stone for building purposes. The stone obtained in making the excavation, which is a work of some magnitude, is employed in the construction of the breakwater.

* Possibly this might be another bed of roach lower in the series than the roach met with in the quarries. As the excavation proceeds this will be ascertained.

† Analogous to the chalk-flints. The deposit of two kinds of matter, *silica* and *carbonate of lime*, from the same waters, or from a soft mass, is due to the tendency which similar particles of matter have to accumulate in nodules or in certain planes, of which there are examples in every formation. The original soft condition of the flint is proved by the fossilized casts of organisms which are contained within its matrix.

List of Fossils which may be collected at this place :—

Ammonites giganteus. Abundant.
,, *biplex.*
Perna mytiloides. Ditto.
Cardium dissimile. Ditto.
,, A small species found on the surface of the flint.
Trigonia gibbosa.
,, *incurva.*
Ostrea expansa, Sow. (?)
Lithodomus Portlandicus.
Unicardium.
Modiola pallida.
Coral. *Isastrea oblonga.*

Beds of Building Stone.

Bed 14.—Base Bed, or Lower Tier.—This, from its greater depth, is not so generally worked as the beds to be hereafter described. Compared with the layer above, it is whiter in colour, finer in grain, more absorbent, and softer. This latter property, while it lessens its value for outside work, increases it for statuary and interiors. In some quarries this bed has been worked to a great extent, and sold for the best stone.

At Upway and Preston the corresponding bed is known as the "White Freestone." In North Wilts the same bed is white like ordinary chalk, and in the Vale of Wardour, one stratum of Portland stone bears so close a resemblance to chalk, as to be called by that name.

In the Portland beds of the Island of Purbeck, there is overlying the freestone a layer of oyster shells (*ostrea solitaria*), eight feet in thickness, cemented together into one mass. This bed may be seen in the cliffs at Tilly-Whim.

A middle or "curf" bed occurs between the two tiers of good stone, but only in the southernmost quarries on the east cliff. The entire thickness of stone, though thus divisible, is not thereby increased.

In the Grove quarry (Red croft), the "curf" is divided by a band of oyster-shells, about 15 inches from the top; and by a second band 2½ feet below the upper. It is an oolitic stone, soft in a northerly direction, but harder towards the south.

The bed is of superior quality to the adjacent freestone, but like all the beds containing flint, or lying adjacent to it, it will not stand the weather. The weight per cubic foot is 145 lbs.·9 oz.

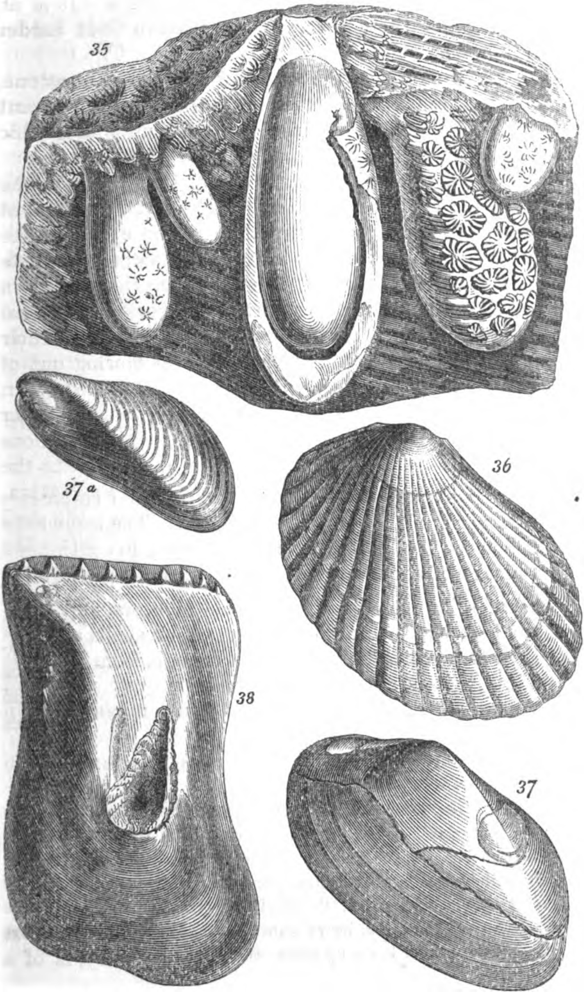
Fig. 35 represents some fossil remains found in the "curf" bed, which I believe are peculiar to the Island of Portland; but where, in quarries on the N. E. side of the island, they are not uncommon. They appear to be casts of *Lithodomi* (a genus of boring molluscs), encased in stone, the surface of which is generally covered with a coral —probably the *Isastrea oblonga*, Plate 8, Fig. 10. Their curious position, more or less erect, as if growing out of the stone, and grouped as above, may be explained by an examination of a portion of rock taken from low-water mark, that has been pierced by *Pholadidæ*, the perforations of which will be found to be nearly perpendicular to the surface. In the case of the Portland oolite sea-bottom, it would seem that these perforations containing the shell became filled with a stony sediment, not only *within* the valves but on their outside, filling the space between the shell and its walls. The intervening portion of the rock or clay thus burrowed, having disappeared after the filling up and consolidation of the crypts, the latter alone remained; a careful removal of the coating will sometimes expose an impression of the hinge and contour of the shell. The presence of corals and lithodomi are evidences of a shallow sea.

[For Woodcut see page 79.]

35. Group of *Lithodomi* covered with coral (*Isastrea oblongo*). Slightly reduced.
36. *Lima Coodei*. N. sp. Slightly reduced.
37*a*. *Modiola pallida*. Nat. size,
37. *Corbicella Portlandica*. N. sp. do.
38. *Perna mytiloides*. Reduced.

Bed 13.—Whit Bed or Upper Tier.—This bed, the best stone that the island produces in point of quality, is of a

Fossils from the Portland Stone, Island of Portland



whitish-brown colour when first raised, but becomes paler on parting with its quarry-water. It is free from shells and hard veins, though varying in texture from a fine close grain to an oolitic or roe-like structure. The bottom part of the whit bed in the west-cliff quarries is observed to be softer towards the south. It is from this upper tier that most of the stone quarried in the island is obtained. The depth as well as the quality, both of this and the lower tier, differs considerably in the various quarries, and sometimes in the same quarries. Both exist to a greater depth in the west-cliff quarries than in those of the east cliff. The N. E. part of the island is considered to yield the best quality of stone. The stone of each tier is said to be hardest towards the upper part. The workmen profess to know the quality of the stone by the sound which follows the stroke of a hammer; the best blocks ringing with a clear musical note.

The weight of a cubic foot of the whit bed, from Vern St. quarry is 134lbs. 10oz.

Ditto Waycroft quarry 135·8lbs.

The price at the quarry, squared and ready for shipment, is 1*s.* 4*d.* per cubic foot,* or 20*s.* per ton. The same sells in London for 2*s.* 3*d.* per cubic foot. Being in continuous beds, blocks of almost any dimensions may be procured?†

Roach.—Bed 12, *c.* hard, somewhat siliceous and bituminous bed, but so crowded with casts of shells as to be unsuited for architectural purposes, though, from its great durability,‡ it is admirably adapted for quay walls and other uses, where a smooth surface is not necessary. In

* In the year 1770 it sold for 9*d.* a cubic foot. In that year 9000 tons of stone were shipped from the island.

† Sir C. Wren, in speaking of the Portland stone, says, "All the most eminent masons of England were of opinion that stone of the largest scantlings were to be obtained there or nowhere."

‡ Its suitableness for fortification purposes was recently tested in the Isle of Portland. Blocks of the roach and others of Cornish granite being exposed to the fire of heavy guns from H.M.S. Blenheim, it was found that the former broke up more readily than the latter.

its native bed it is incorporated with the good stone that lies below, and which in working is separated from it.

Blocks of any practicable size can be produced. The weight of a cubic foot of Roach taken from "Goslings Quarry," is 126 lbs. 13 oz. The price at the quarry, 6*d*. per foot, or 8*s*. per ton.

The Roach does not offer the same character out of the island.* As none of the species of fossil shells found in the Roach occur in any later formation, it may be presumed they became extinct when that bed was raised out of the sea. The casts, though so abundant, rarely retain a vestige of the shell, the original of which after the consolidation of the mass decomposed leaving an empty cavity, and an impression of its outer shell upon the surrounding matrix. All that remains, therefore, are casts of the inside of the original shell, which correspond to what may be produced by filling a recent shell, and afterwards surrounding it with plastic matter: when it had undergone the process of hardening, and the shell became decomposed, there would be remaining,

Firstly. An interior cast presenting a counterpart of the original shell. *Secondly*. An impression on the surrounding mass corresponding to the markings of the external surface. Figs. 2 and 3, Plate 7.

b. Layer of flint in which occur the same species of fossil shells as those found in the bed below. These fossils, which occur on the surface of the flint, retain their outer shell, and are preserved in Chalcedony.

* At Swindon the Portland stone is not so uniformly capped with the Purbecks or Freshwater limestone as in the Isle of Portland, which may explain the difference of the two formations. The Portland area when raised from the sea formed the bottom of a fresh-water lake, whence it received a calcareo-siliceous deposit, that MM. Cuvier and Brongniart have observed as characterising the waters of ancient lakes. This has enveloped and cemented into one mass accumulations of marine shells (P. roach), that in Wiltshire appears to have been raised so as to form dry land, since in that district a bed composed almost entirely of casts of shells like those of the Portland roach forms there a loose and incoherent mass.

a. The upper portion, for a few inches in depth, is of an oolitic structure and uniform texture, light-brown colour, and free from fossils.

The chemical composition of the top bed of the Portland stone, as analysed by Professor Daniell, is,—

Silica	1·20
Carbonate of Lime . .	95·16
Carbonate of Magnesia .	1·20
Iron and Alumina . .	0·50
Water and loss . .	1·94
Bitumen	a trace
	100·00

The prevailing fossils of the Roach* are *Trigonia*† *gibbosa*, *Cerithium Portlandicum*, *Lucina Portlandica*, *Buccinum naticoides*, *Natica elegans*, *Pecten lamellosus*, *Ostrea expansa*, *Plicatula*, *Sowerbia Dukei*.

Fossils from the Portland Stone, Isle of Portland.

Reptilia.

Plesiosaurus megapleuron, Owen. Vertebræ and other bones.

Fishes.

Pycnodus Bucklandi, Ag. Palatal teeth and vertebræ.

* The corresponding bed in Wiltshire contains nearly the same species as at Portland, but differing in their relative proportion.

Near Boulogne, the utmost known limit of the Portland series, the upper beds contain the same species as on this side of the English Channel. Some of the second-rate streets, I observed, were paved with the Portland stone, containing numerous casts of *Trigonia gibbosa*—*Cerithium Portlandicum*, &c.

† A genus of which 100 species are known, distributed through the secondary rocks up to horizon of the Greensand, when they disappear. The genus is nowhere found in Tertiary strata, but it reappears in existing seas. *Trigonia pectinata*, a shell with a pearly interior, rich colour, and of singular beauty, occurs in Swan River, New South Wales.

Cephalopoda.

Ammonites giganteus, Sow.
,, *triplex*, Morris.
,, *biplex*, Sow.

Gasteropoda.

Cerithium Portlandicum, Sow.
,, *concavum* (*Turritella*, Sow).
Pleurotomaria (*Trochus*) *rugata*, Bennett.
Buccinum naticoides, Sow.
Pterocera Oceani, Brong.
(*Buccinum angulatum*, Sow).
Natica elegans, Sow.
Neritoma sinuosa, Morris.

Conchifera.

Trigonia gibbosa, Sow.
,, *incurva*, Sow.
Pecten lamellosus, Sow.
Perna mytiloides, Lam.
Plicatula (?)
Lithodomus Portlandicus. N. sp.
Lucina Portlandica, Sow.
Cytherea rugosa, Sow. Rare at Portland, but most numerous in the P. stone of Wiltshire.
Myacites Jurasii, Brong.
Cardium dissimile, Sow.
Ostrea expansa, Sow.
Sowerbia Dukei. N. sp.
Lima Coodei. N. sp.
,, (*Plagiostoma*) *rustica*, Sow.
Corbicella Portlandica. N. sp.
Unicardium circulare, D'Orb.
Mytilus. (?)
Modiola pallida, Sow.

Annelida.

Seprula, *triserrata*, Sow.

Corals.

Isastrea oblonga, Fleming (on casts of Lithodomi).
Serpulæ.

The annual consumption from the whole of the quarries in the island was, in the year 1839, reported at 24,000 tons, equal to an area of one acre of good stone; the entire area remaining unworked, being estimated at 2,000 acres. In 1855 the quantity of stone conveyed on the Portland Railway was,

Block . . .	22,995	tons.
Roach . . .	3,547	„

besides a few hundred tons shipped from other parts of the island.

The present annual consumption exceeds 40,000 tons, exclusive of the stone quarried by the convicts of the Portland prison, and employed in the construction of the breakwater, or considerably more than a thousand tons for each working day.

The quality and durability of the Portland stone, like those of other oolitic limestones, depend very much on the nature of the cementing matter by which the oviform particles are held together. The hardest beds have their cementing matter in a solid and partially crystallized form. In the softer stone the cementing matter is in an earthy, friable, or powdery state; hence on exposure to the effects of the atmosphere, it more readily suffers decomposition than does the former.

An interesting account of the stone quarries of Portland is given by Smeaton, who visited them previous to the building of the Eddystone lighthouse. This narrative, though written a century ago, is in most particulars applicable to the present time. The mode of working the stone appears to have undergone no change. The tools and appliances made use of (with the exception of a modern crane) remain the same.

Report with Reference to the Selection of Stone for the Building of the two Houses of Parliament. Presented March 1839.

St. Paul's Cathedral, London. Finished about 1700. Built of Portland oolite from the Grove quarries on the east cliff. The building generally in good condition, especially the north and east fronts. The carvings of flowers, fruits, and other ornaments, are throughout nearly as perfect as when first executed, although much blackened. On the south and west fronts larger portions of the stone may be observed of their natural colour than on the north and east fronts, occasioned by a very slight decomposition of the surface. The stone in the drum of the dome and in the cupola above appears not to have been so well selected as the rest; nevertheless, scarcely any appreciable decay has taken place in those parts.

PORTLAND. *New Church,* built 1776. Portland oolite. Fine roach. In a perfect state of preservation, exhibiting the original tool-marks.

Old Church. In ruins, near Bow and Arrow Castle (15th century); of Portland oolite, resembling top bed; in very good condition; original tool-marks still appear in the north front.'

Bow and Arrow Castle. Many centuries old; of Portland oolite. The ashlar resembles the top bed, and is in perfect condition; the quoins and corbels of the machicolated parapet appear to be of the cap bed of Portland oolite, and are in good condition.

Wyke Church (15th century). Of oolite similar to Portland; the whole in good condition, execept the mullions, tracery, and dressings of doors and windows, which are constructed of a soft material, and are all decomposed. On the south side the ashlar is in part covered with rough cast. The entire building is thickly covered with lichen.

Sandsfoot Castle, near Weymouth, constructed of Portland oolite in the time of Henry VIII., is an example of that material in excellent condition; a few decomposed stones used in the interior, and which are exceptions to this fact, being from another oolite in the immediate vicinity of the castle.

The report, from which the above extracts are taken, states that buildings situated in the country possess a great advantage over those in populous and smoky towns, owing to lichens, with which they are covered in such situations, and which seem to exercise a protective influence against the ordinary causes of the decomposition of the stone upon which they grow. As an instance of the difference of degree of durability in the same material, according as it is exposed to the effects of the atmosphere in town or country, they call attention to the several frustra of columns, and other blocks of stone, which were quarried at the time of the erection of St. Paul's Cathedral, and are now lying in the Isle of Portland, near the quarries from whence they were obtained. These blocks are covered with lichens, and though they have been exposed to all the vicissitudes of a marine atmosphere for more than 150 years, they still exhibit, beneath the lichens, their orginal form, even to the marks of the chisel employed upon them ; whilst the stone which was taken from the same quarries and placed in the cathedral itself, is, in those parts which are exposed to the south and south-west winds, found in many instances to be fast mouldering away.

Sections of Quarries in Portland.

Section of *Grove Quarry*, *Red croft*.

	Feet.	Inches.
Rubble . . .	7	8
Dirt-bed . .	1	0
Roach . . .	1	6
Top bed . .	4	0
Middle or Curf bed	5	6
Bottom bed . .	7	0

Layer of dark flint separating the two beds of good stone.

Waycroft Quarries.

	Feet.	Inches.
Rubble, &c.	8	0
Dirt-bed	1	0
Top cap	4	6
Skull cap	2	6
Roach	3	0
Top bed	7	6
Loose stone and flint . .	7	0
Shelly stone	2	0
Bottom bed	5	6

From the top bed of this quarry, Goldsmith's Hall and the Reform Club House, in London were built.

Maggot Quarry.

	Feet.	Inches.
Rubble, &c.	8	0
Dirt-bed	1	0
Cap	7	0
Skull cap	2	0
Roach	2	6
Top bed	8	6
Loose stone and flint . .	7	0
Bottom bed	7	0

Goslings Quarry.

Rubble, &c.	8	0
Dirt-bed	1	0
Top cap	6	0
Skull cap	2	0
Roach	4	0
Top bed	8	0
Rubbish bed with layers of flint.		
Bottom bed, very soft.		

The Portland beds at Upway contain the following species :—

Pycnodus Bucklandi. Palatal teeth.
Ammonites giganteus.
Pleurotomaria rugata.
Buccinum naticoides. (?)
Cardium dissimile.
Pecten lamellosus.
Myacites Jurasii.
Trigonia gibbosa.
,, *incurva.*

A thin seam of clay, termed by the quarrymen "scum," containing no organic remains, but it is of interest as separating the Marine (Portland stone) from the Freshwater (Purbeck formation). This slight deposit, spread over the whole of the top of the Portland series, is the first indication of the emergence of the Portland beds from beneath the sea.

These layers, of clay or "dirt" characterise the Purbeck strata; and here, as well as at Ridgway, Lulworth, and Durlestone Bay, generally alternate with the beds of limestone. At Ridgway, however, this particular layer is absent, and the Portland and Purbeck series unite in a layer of hard stone, less than a foot in thickness, but presenting the remarkable condition of a solid stratum, the upper part of which is of Freshwater, the lower of Marine origin.*

PURBECK FORMATION.†

Skull Cap.

Bed 11.—The term "skull cap," applied to the solid layers constituting the lowest bed of the Purbeck formation is intended to denote its position in relation to other beds below. It is a hard cream-coloured limestone of irregular texture, full of minute cavities lined with crystallized carbonate of lime, of very variable thickness, and with an undulating or lenticular form. In some places it is not more than a foot thick, but sometimes it suddenly swells in a short horizontal distance to a thickness of two and even three feet.

This complete covering of the Portland oolite with a freshwater deposit, corresponds to what may be seen at the base of the Purbeck series at Ridgway, Lulworth Cove, Durlestone Bay, &c.

Bed 10.—Lower Dirt-Bed, or "dirt below the cap," as

* At Chicksgrove, S. Wilts, the junction of the Portland and Purbeck formations is also without the intervention of clay or dirt, as shown by a specimen from Wockley near Tisbury, amongst the rock specimens in the Museum of Economic Geology.

† A more detailed account of the Purbeck series will be found in a future chapter.

separated by the "cap" stone from the upper or great dirt-bed. Cycadeæ, of the same species as those from the upper dirt-bed, though found in this deposit, generally penetrating into the solid stone above, are not of frequent occurrence. No fossil trees are met with in this lower dirt-bed, though Dr. Fitton* relies upon a prostrate trunk having been taken from the "dirt" below the cap, in his description of a section of the Portland beds exposed on the west side of the road leading from Upton to Poxwell. The deposit bears more of a clayey than an earthy character, and never, as far as I could detect, contains any portions of carbonaceous matter, such as characterise the upper or great dirt-bed.

Bed 9.—Cap, or "top cap," is the thickest bed of all the Purbeck series; † it is white, hard, and of irregular structure. Neither this nor the "skull cap" has an oolitic structure like the Portland stone, but is of a closer and flinty texture, a quality which prevents its being easily worked; partly for which reason, and partly on account of the abundance of other stone, this bed is neglected. The upper portion which separates from the main bed, and is called the "upper rising," is of unequal thickness. Its surface is more or less coated with stalagmite, and for about 18 inches readily splits into slabs. Towards the base it assumes a porous structure, traversed with sinuous cavities or perforations, perpendicular to the surface of the stratum.‡ Other cavities are filled with globules of carbonate of lime.§

* 'Geo. Trans..' new series, vol. iv. p. 222.

† At Mewps Bay the corresponding bed is 8 feet in thickness, and is overlaid by the dirt-bed with cycadeæ.

‡ This form of deposit in its most porous state is known as "Calcareous Tufa;" when it takes the more solid form, as "Travertin," the limestone which in Italy has acquired the name of "Travertino," and of which the Coliseum and many other ancient works in Rome are constructed.

§ These cavities in freshwater limestone are considered by M. Beudant as having been caused by the disengagement of gas ('Geo. Trans.' vol. ii. p. 83), but, this having been formed at the bottom of a

The small Cyclades, the only fossils found in the "cap," are not numerous in the Isle of Portland, but occur most abundantly in the Purbeck strata at Ridgway and Lulworth.

GREAT DIRT-BED. BED 8.—Mr. Webster (Geo. Trans., vol. ii. part 1) was the first to point out the singular character of the earthy deposit known as the "*Dirt-Bed.*" It had been previously supposed that the fossil trees, cycadeæ, were from the oolite itself, whereas the Dirt-Bed is the actual soil in which they grew and in which their remains occur. This soil, which nourished the roots of an ancient forest, is a bed of about a foot in thickness, of a dark-grey colour, not black, as generally described, but containing patches of a jet-black substance like soot, which appears to have been deposited at a later time, as so light a substance could not have retained its present character when covered with water. The great interest attaching to the Portland Dirt-Bed is not in consequence of the mere accumulation itself, as terrestrial deposits must necessarily have occurred at every geological period, but from the fact of its preservation, and that between beds of stone, as the change of condition consequent upon the transition from one formation to another might be expected to disperse such an earthy material.*

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freshwater-lake, dry land was near, and therefore drifted branches and other portions of trees might have been imbedded, and, decaying after the partial consolidation of the sediment, might have left these spaces.

* Sir R. Murchison (Geology of Russia, vol. i. p. 560) gives an account of the Tchornozem, or Black earth, of central Russia, which for extent and uniformity in colour and composition is without parallel. It covers an area of many hundreds of square miles, of a thickness varying from a few feet to 20. In journeying over these dry tracts, in a dry summer, says a traveller, " we were surrounded by a black dust which is of so subtil a nature as to rise through the so under the stamp of the horses' feet, and forms so dense a cloud that we were begrimed like working colliers." By some this deposit is supposed to be derived from the decomposition of trees, etc. Sir R. Murchison considers it of marine, and not terrestrial origin, and derived from the

Extent and Range.—Besides the Isle of Portland, the Dirt-Bed occurs in the cliff east of Lulworth Cove. At Ridgway it is less distinctly represented, and is separated from the "Cap" by a layer of soft chalk-like stone. Beyond this district it is found at Swindon * in Wilts, Thame in Oxfordshire, and in Buckinghamshire. Out of England it has hitherto only been observed on the coast near Boulogne ;† but in none of these places is it so well developed as in the Isle of Portland, where the trees and plants are not only found upright in the spots on which they flourished, but even the soil in which they grew still retains much of its primitive character.

FOSSILS OF THE DIRT-BED.—See Plate 2. *Cycadites.* (From *Cycas*, an ancient Greek name for plant.)

These singular vegetable productions, so abundant in the Dirt-Bed of the Isle of Portland, are better known as fossil 'crows'-nests' to the quarrymen, who regard them as the nests dislodged from the petrified trees with which

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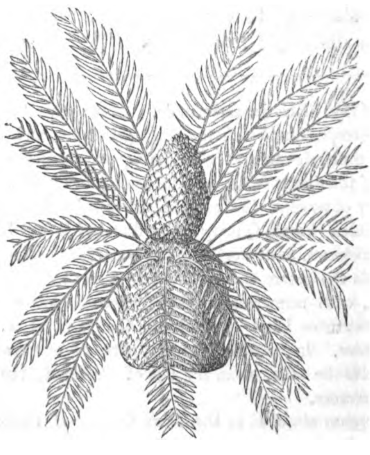
destruction of the black Jurassic shale. Ehrenberg, in examining it under a microscope, found 6 forms of *Polygastrica*, and 22 of *Phytolitharia*, and concludes that it is not an aqueous deposit, but rather a soil formed of the debris of an ancient forest, an origin hypothetically given by early observers. 'Edin. Phil. Journal,' vol. li. p. 394.

* At Swindon (Parish Quarry), the dirt-bed is not horizontal and of uniform thickness, as at Portland, but occupies a basin-shaped cavity, which towards the centre is from 3 feet to 4 feet in thickness of variegated colour, with numerous specks of carbonaceous matter, and at places it constitutes larger deposits in the form of a deep brown-coloured powder. In another quarry, portions of trees in an erect position were to be seen, as in the Isle of Portland, but were not of common occurrence.

† The museum attached to the Town College of Boulogne contains specimens of silicified coniferous trees, which were found in a stratum of tough dark-coloured clay, overlying the Portland beds, and not distinguishable from those of the Isle of Portland. This museum, though extremely rich in illustrations of the Geology of the district, does not include specimens of cycadeæ ; from which it may be inferred, that the fossil in question has not been discovered in that locality.

they are associated. Sir J. Smith, in describing a recent cycas, which bore fruit at Farnham in the year 1799, makes the same comparison.* These fossil plants are allied to the existing family of *Cycadeæ*, and belong to two genera, viz., *Cycas* and *Zamia*. Five species are recorded of the first genus, and of the second, seventeen. From their resemblance to this group, Dr. Buckland proposes the name *Cycadeoideæ*;† M. Blainville has assigned to them a genus termed *Mantellia*; Mr. Brown, from the result of a comparison with the living cycas and zami,‡ considers that until sufficient reasons are given for separating them from these genera, the general term *Cycadites* is more appropriate.

Fig. 39.



Zamia pungens. (Living species.) Habitat, Cape of Good Hope.

* 'Transactions Lin. Soc.' Plate 29, p. 312.

† Bridgewater Treatise, vol. i. p. 496. Note.

‡ *Zamia horrida*, or Hottentot Bread-fruit plant, is one of the species.

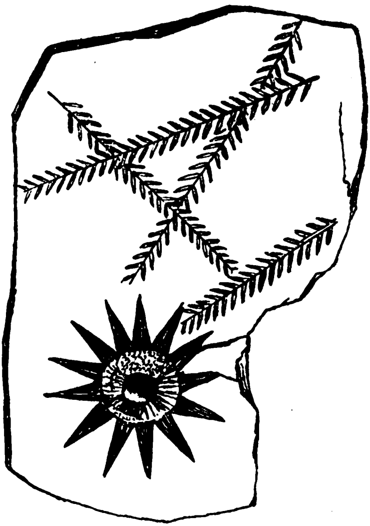
Fig. 40.

Cycas revoluta. (Living species.) Habitat, Tropics.

Figures of both these species found in the Isle of Portland appear in Plate 8, figs. 1 and 2. They vary in size from 6 inches to 12 inches in height, and from 9 to 12 inches in diameter, and have a hollow concentric cavity at the top. The numerous scales surrounding the trunk (not usually so distinctly seen as in the specimen figured) form the bases of the leaf-stalks. As yet no leaves of the species under consideration have been discovered, though both stems and leaves of other cycadeæ have been found both in the great oolite and lias.

Fig. 41.

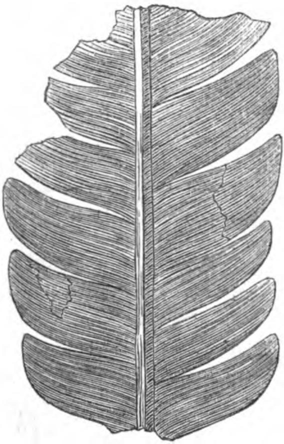
From a Specimen in the collection of John Leckenby, Esq.



Pterophyllum (cycadites) pecten. Oolite. Scarborough.

Fig. 42.

From a Specimen in the collection of John Leckenby, Esq.



Pterophyllum (cycadites) comptum. Oolite. Scarborough.

In the *Cycas revoluta* (fig. 40), from the scars or scales which protrude near the margin, spring the leaves, which, like those of the pine-apple, crown the summit of the plant, and correspond to the cavity which characterizes the Portland cycadeæ. As the living species of this family of plants inhabit India, New Holland, and the Cape of Good Hope, it may be supposed that the climate of this area was once of a temperature somewhat similar to that of those regions.

Fossil Trees.—Cycadeæ occur in both the upper and lower dirt-beds. Trees are found only in the upper or Great Dirt-bed. From the number and position of their remains they appear to have grown as close to each other as the trees of a modern forest.*

* Lieut. Newbold describes a large accumulation of fossilized trees in the Suez Desert near Cairo; and there called the "petrified forest." He mentions one specimen, in particular, as measuring 61 feet long and

The prostrate trunks lie near the stumps from which they had been severed. The latter, many of which are of great bulk, still stand erect in their original positions, and from their roots filling cavities in the underlying stone, the latter must have been in a soft state, ere the trees reached maturity. The fallen portions generally lie in the direction of the length of the island, that is, nearly north and south. The petrifying or fossilizing matter of both trees and cycadeæ is silex, for though surrounded with carbonate of lime above and below, they are composed almost entirely of silica.* Some specimens of the trees are covered with quartz crystals, and transverse sections exhibit the cellular cavities filled with siliceous matter. Dr. Prout, in a chemical analysis, found them to consist almost wholly of silica, with very slight traces of carbonate of lime and iron. Some of the darker parts contain a portion of bituminous matter. The concentric rings marking their annual growth are very distinctly preserved. The trees all belong to the family of *Coniferæ* (pine family), trees that bear cones, in which the seeds are contained, and like the cycadeæ, they require for their growth a

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5 feet round, and as completely silicified as the Portland coniferæ. Similar remains, Lieut. Newbold states, are found in the Nubian Desert; but in neither could he trace them, like those of Portland, to a root fixed in a given stratum, nor could any vegetable soil be detected. 'Geo. Pro.' vol. iv. p. 350.

Sir Robert McClure mentions, in his narrative of the discovery of the north-west passage, the existence of a fossil forest on Banks' Land, lat. 74° 25' N., where, for a depth of 40 feet, the cliff was composed of one mass of fossil trees * * * * * "120 miles further north, we discovered a similar kind of fossil forest."

* MM. Cuvier and Brongniart, in their essay on the Geology of Paris (p. 56), state that the fresh water of the ancient world possessed properties which are not observed in that of our modern lakes: in the latter we find deposits of a friable kind only; but in the lakes of ancient date, we have, in addition to other substances, flint, which has enveloped organic remains, and converted the original structure into a siliceous matrix, which surrounds them.

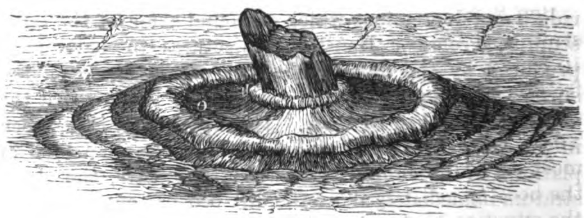
higher temperature than is now prevailing in Great Britain. The existence of pines and cycadeous plants, and the numerous minor forms of vegetation which once flourished in the Portland of ancient days, is in striking contrast with the sterile character of the present surface of the island, where, with the sole exception of the grounds around Pennsylvania Castle, and a few recently cultivated spots, scarcely a tree or shrub is to be seen.

The singular condition of the stone overlying the dirt-bed remains to be noticed. The latter not being more than a foot in thickness, while some of the trunks are three feet in length, and still retain their erect positions, it follows that their upper portions must either penetrate into the stone above (soft burr), or that the latter must have been deposited and consolidated around them.

The presence of these upright portions is indicated by a rise or mound in the stratum of stone above. The circular ridges and depressions which surround some of the taller stumps, Professor Henslow conjectures to have been produced by the disturbance they would cause on the surface of the water, which was then so shallow that the waves were broken by them. This appearance is also seen in the "Fossil Forest," at Lulworth, where, on a kind of platform in the cliff, a little east of the cove, the stony stratum immediately above the dirt-bed has enveloped the cycadean stools, forming circular or dome-shaped masses of great size: in some instances the vegetable structure is preserved, in others a conical cavity is left, the stone having consolidated before the cycadeæ perished. These formations are very numerous, and have a remarkable appearance. The familiar drawing of this site—Geo. Trans. vol. vi. 2nd series, page 14, and repeated in so many geological works—is to some extent imaginary, as no erect stumps of trees in their native soil are to be seen, nor even a fragment of fossil wood, though it may be presumed that trees were associated with the cycadeæ. The observer will here also notice some stools of an elliptical form with an inner depression, as if the stone had consolidated over a prostrate trunk which subsequently perished. Pebbles,* and larger fragments of stone apparently derived from the flint-beds beneath, are numerous in the dirt-beds; but no organic remains other than those mentioned have hitherto been discovered.

Bed 7. Soft Burr.—The consolidated sediment which, after their submergence in fresh water, enveloped the trees and cycadeæ; the upright stumps of which penetrate the "Burr," causing the inequalities and swellings in the stone, represented in Fig. 43. Around the trunks, and between them and the "Burr," there is generally a small space filled with carbonaceous matter, the residuum of the outer portion of the tree. The Burr is a soft stone; "it stands fire," and is used for chimney-work and fire-places. It contains no fossils.

Fig. 43.



Drawing of the erect stump of a tree, protruding through the "Burr stone" into the stratum above called the "Aish," from Buckland and De la Beche, Memoir, p. 16.

Bed 6. Aish.—Though associated with the "Burr," this bed, from its fissile or slaty character, is easily separated from it. The tops of the longer stumps of trees

* It has been conjectured that a salt-water lake existed adjacent to the dirt-bed, and that to its encroachment during storms is due the rolled pebbles found in the latter. Robertson on the Wealden, Geo. Pro. vol. iii. p. 120.

pass through the "Burr" into the "Aish:" the uneven surface of which often serves to indicate the presence of the trees beneath. It has been observed that the stone of both the "Aish" and the "Burr," when in contact with the trees, is harder and more flinty than is the case elsewhere.

Bed 5.—"Clay," parting.

Bed 4.—Bacon Tier differs from the subjacent beds in its greater hardness, and in being deposited in bands which are sometimes separated by thin layers of sand. It contains no fossils. The seams of clay and carbonaceous matter repeated above and below the "Bacon tier," and alternating with the solid beds, are of interest, as indicating the occurrence of a succession of changes over that area.

Bed 3.—"Clay" or "Dirt" seam.

Bed 2. Slate.—The deposit constituting the upper stratum of the Isle of Portland, though in Fancy quarry, 10 feet in thickness, varies in other parts of the island from less than 3 feet to 15 feet. It is chiefly made up of a hard stone shivered into layers of about an inch thick. The whole bed is much shattered, and the stratification most irregular, particularly over a "gully," towards which the beds on either side incline sufficiently to determine the situation of one of those openings. This bed is without fossils, though *Cyprides* and *Cyclades* may be supposed to occur, as they are found in the neighbouring localities in nearly all the limestone beds of the Purbeck series.

Fissures.

Rents or "gullies" traverse the stony beds in a direction from north-east to south-west (Fig. 34). These fissures, which extend across the island, vary in width from one foot to several feet, and are accompanied by minor cracks running in the same direction, which latter greatly facilitate the quarrying of the beds of marketable stone. The upper portions of the "gullies" are generally filled with rubbish formed of the coarser materials derived from the overlying beds, the slaty strata immediately above the chasms being either disjointed or greatly inclined on both sides towards the gully (Fig. 34). In some places, large cavernous spaces communicate with the fissures, caused probably by the severance of masses of rock that have disappeared in the openings below. Similar fissures occur in this formation at Brill in Oxfordshire,* attended by a similar derangement of the overlying strata. At Swindon they were filled with loose sand throughout, and are not open as in Portland.†

STALACTITE—(from σταλάζω, to drop) is formed by dropping water charged with calcareous matter in solution. All rain water contains carbonic acid, which, when passing through strata containing lime, forms a soluble *bi-carbonate.* In dropping from the roofs of caverns, evaporation of the watery particles takes place, and the solid portion which remains behind forms stalactitic pendants, which hang like icicles. Their component parts are determined by the nature of the strata through which the water passes. At Portland they are composed of a bi-carbonate of lime,‡ of an amber colour, the latter character being caused by the diffusion of oxide of iron. A beautifully crystallized form of calcareous spar, not uncommon, is composed of an aggregation of long slender translucent crystals, of a bright amber colour, and breaking with the

* 'Geo. Trans.' second series, vol. iv. p. 255.

† Fissures in rocks of volcanic origin, are supposed to be occasioned by their contraction, while passing from a heated to a cool state. Their occurrence in stratified rocks may arise from the violent tension to which the solid strata would be subjected during its upheaval, a tension that could only be relieved by a rent or fracture. In the latter instance, it is not uncommon to find the face of each side of the opening either polished or scratched from the rubbing together of the two sides. Another result is the horizontal displacement of the strata, *i. e.*, a sinking or depression of the beds, on one side of the fracture, which sometimes amounts to several hundred feet. The continuity of the strata in the Portland fissures is but little interrupted.

‡ In the caves of Matlock, they are formed of sulphate of barytes.

rhomboidal fracture peculiar to crystallized carbonate of lime. Colourless crystals of the variety called *dogtooth-spar* are also found.

Stalagmite (from στάλαγμα, a drop).—When the water drops too quickly from the roof to allow of the formation of a stalactite, the deposit takes place on the floor on which it falls, and is then called stalagmite. In this latter form it is known by the Portland quarrymen as *sugar-candy*, *cauliflower*, &c. It is not uncommon to find stalactites that attain such a length as to become united with the stalagmite; and thus by the gradual accumulation of infiltrating matter, as in the manner here pointed out, the whole fissure or cavity becomes entirely filled with a solid mass of hard calcareous matter. The stalagmitic carbonate of lime, which has been deposited in this manner, and is quarried in some parts of Egypt in masses large enough for statuary purposes, is called *oriental alabaster*.*

PURBECK FORMATION.

This formation was until lately included in the Wealden, but at the suggestion of Prof. Edward Forbes it is now considered to form a part of the Oolitic series. It consists of limestones, shales, and sandstones, with clay partings, and is divided into an *upper*, *middle*, and *lower* series, exhibiting alternations of brackish and salt-water, or marine deposits, with soils formed on dry land. At the meeting of the British Association held in 1850, Professor E. Forbes communicated the results of his investigation 'On the succession of strata and distribution of organic remains in the Dorsetshire Purbecks,' which in a more extended form, will probably appear in the Memoirs of the Geological Survey. The chief localities at which his observations were made are Ridgway, Osmington, Lul-

* The magnificent sarcophagus in Sir John Soane's museum, brought from Egypt by the traveller Belzoni, is composed of a stalagmitic cavern-deposit of this nature.

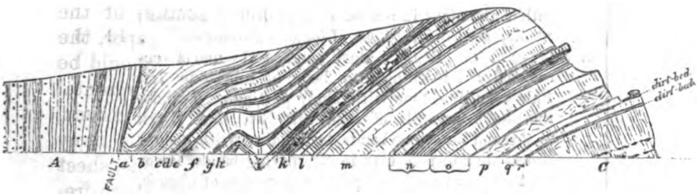
worth Cove, Worbarrow Bay, Durlestone Bay, and Mewps Bay. The latter place Professor Forbes considered to exhibit the most distinct and complete section of the Purbeck formation. In addition to the above paper, the excellent Memoir of the Rev. Osmond Fisher * should be consulted, and the recent beautifully-executed horizontal and vertical sections of the strata of the Isle of Purbeck, by H. W. Bristow, Esq., F.G.S., of the Geological Survey (Horizontal Sections, sheet 56, and Vertical Sections, sheet No. 22). Lulworth Cove being a favourite and much-frequented spot, and the beds there being singularly convenient for examination, it has been here selected for description in preference to the other above-mentioned points.

No fewer than nine distint sections of the Purbeck strata are to be seen in and near Lulworth Cove. A steamer runs from Weymouth to Lulworth every Wednesday during the summer,† and from the latter place a boat should be taken to obtain a sea-view of the very interesting geological features displayed on this portion of the coast, where the Purbeck and the Chalk formations offer every degree of inclination from the horizontal to the vertical; while from their unequal degree of hardness, arches, caverns, peaks, and other singularly shaped rocks, have been produced, which have been already referred to and illustrated in the introductory chapter.

* On the Purbeck Strata of Dorsetshire, by the Rev. Osmond Fisher, M.A., F.G.S. 'Transactions of the Cambridge Phil. Society,' vol. ix.

† The distance from Weymouth to Lulworth across the bay is a little less than 10 miles. By road it is 16 miles. It may also be reached partly by rail, stopping either at Wool or Wareham stations. From Wool to West Lulworth, passing through the grounds of Lulworth castle, (castle open to the public on Wednesdays,) is 5 miles. From Wareham the distance is 8 miles; here, though not at Wool, a conveyance may be had.

North. *Fig. 44.* *South.*



Section of the Coast on the East Side of Lulworth Cove.

DESCENDING SECTION.

Chalk and Upper Greensand behind, forming the north side of the cove, and not shewn in the above Fig.

A Hastings sands and Weald clay, forming vertical beds.

			ft.	in.
UPPER.	*a*	PALUDINA CLAYS. Paludina limestone. FISH, *Pycnodus*	2	3
	b	UPPER CYPRIS CLAYS AND SHALES . . .	13	6
	c	UNIO BEDS. Soft green shale full of Unio. Bands of hard limestone. "Beef," shelly limestone and dark-grey shales	7	9
	d	BROKEN-SHELL LIMESTONE. Fish, teeth, and palates, very numerous scales (*Pycnodus*): Shells *Paludina*, *Limnæa*, &c.	3	6
MIDDLE.	*e*	CHIEF BEEF BEDS. Bands of dark soft Clay, hard shell-limestone *Cyrena*. Beef with lines of perished shells	8	3
	f	CORBULA BEDS. Hard limestone, covered with fish-spines (*Asteracanthus*), 1ft. 9in. Shells, *Oysters*, *Pecten*, *Cyrena*. Dark grey shales . . .	15	0
	g	SCOLLOP BEDS. Hard shell-limestone . .	1	10
		INTERMARINE BEDS. Dark shales with lines of perished shells 2ft. 2in. Bands of hard limestone. Beef	7	6
	i	CINDER.* Soft cinder, 1ft. 6in. Hard cinder, vast accumulation of *Ostrea distorta* . . .	4	0
	k	CHERTY FRESHWATER. Dark sandy shales, 2ft. Cream-white limestone, with 3 distinct layers of black chert	5	9

* On the summit of this bed in Mewps Bay, Prof. Forbes discovered the first Echinoderm ever seen in the Purbeck series, *Hemicidaris Purbeckensis*. A genus characteristic of the oolite period, and figured in Decades 3 to 5 of the Geological Survey. Mr. Bristow has since found spines and portions of the same species in the corresponding beds in the vale of Wardour.

LOWER.

	ft.	in.
l Marly Freshwater. Bluish shales with thin lines of limestone, 2ft. Towards the centre a band (2ft. 6in.) of pale pink and variegated compact limestone, rather abundant in scales, etc., of fish, *Lepidotus*; Shells, *Hydrobia*, *Physa*, *Limnæa*, *Planorbis* .	12	6
m Soft-cockle Beds. Hard and soft marls occasionally hardening into beds of limestone 7ft. Pale grey limestone with shaly partings. Pseudomorphous crystals of rock salt 3ft. 6in. Dark shales and limestone bands, terminating with a slaty limestone and pale clay in alternating bands, lower part covered with small pebbles, 2 species of *Cypris*, and fish-remains, also pseudomorphus: crystals of rock salt, 13ft. Hard and soft marls. Grey shales and limestone bands. At bottom, hard marl with cavities lined with flint and calcareous spar .	39	0
n Hard-cockle Beds. At top hard fissile limestone with thin layers of crystalline honeycombed limestone, and a shaly parting 4ft. Yellow sandy limestone, very conspicuous from its colour, and mode of weathering; ripple marks on under surface 2ft. Shelly limestones 6ft. Dark sandy shale 2ft.	14	0
o Cypris Freestone. Soft slaty limestone with *Cypris* and carbonaceous specks. Layers of pseudomorphous crystals of rock salt. *Cypris punctata*, *C. Purbeckensis*, Shells *Rissoa*, *Planorbis* 2ft. 6in. Very sandy limestones with casts of fossils 3ft. Shales and limestones, ending with cream-coloured slaty limestone; 5ft.	21	0
Sandy Partings	1	0
p Broken Bands.* Shattered slaty limestone, with included fragments of flint, lines of stratification destroyed	10	0
q Soft Cap. Bands of limestone, undulating over *Cycas-stools* in the bed beneath	5	0
r Hard Cap. Tufaceous limestone, with masses and occasionally layers of flint	4	6
s Dirt Bed	1	0
Total .	176	0†

Oolitic limestone: Fossils, *Ostrea*, *Cardium dissimile*, *Ammonites giganteus*, *&c.*

* On the origin of this very singular bed, the Rev. O. Fisher offers the following suggestion:—That the dirt-bed in its earlier stage was filled with branches of trees and other vegetable accumulations, over which a superficial deposit of mud and other sedimentary matter was thrown down, which subsequently giving way the upper beds fell in upon the vacuity, in the confused manner in which they now appear. —'Cambridge Phil. Trans.'

† At Mewps bay, the total thickness of the Purbeck series is about 155 feet. Edward Forbes.

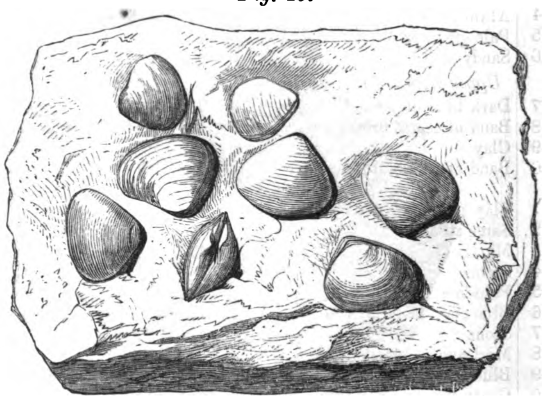
Fig. 46.

Curved Strata at Stare Cove, west of Lulworth Cove.

PORTLAND BEDS (MARINE).

'Beef,' layers of which are so often repeated throughout the Purbeck formation at Ridgway, Lulworth, &c., is a fibrous carbonate of lime, with a texture resembling fossil wood, known to the quarrymen as 'beef,' 'horse-flesh,' 'bacon,' &c. The fibres shoot upwards from the bed of bivalve shells. From this Mr. Fisher supposes their production due to a change in the condition of the shells on which they rest.

Fig. 45.



Purbeck Limestone, with Cyclas.

It will be seen from Fig. 44 that the Purbeck beds at this point are not only raised in common with the adjacent portions of this formation so as to form a considerable dip, but that they are also curiously contorted, either from lateral pressure or partial subsidence.

The following section is copied (by permission) from the valuable Memoir "On the Purbeck Strata of Dorsetshire," by the Rev. Osmond Fisher, already quoted.

SECTION OF PURBECK STRATA, RIDGWAY HILL.

UPPER.

	Character of Rock.	Thickness	Organic Remains.
		ft. in.	
	Paludina clays.		
	Passage of Hastings sands into Purbeck strata, band with lignite		
1	Rubbly rock with iron stain	1 6	
2	Pale green clay	1 0	Paludina
3	Paludina marl	1 6	
4	Alum shale parting	0 6	Fish-teeth
5	Pale green paludina marl	0 10	
6	Sandy shale	0 6	Cypris
	Upper Cypris shales & clays		
7	Dark blue clay	4 0	
8	Band of coarse brown stone	0 4	Turtle, Fish-scales,
9	Clay	0 10	
10	Band of coarse stone	0 6	Turtle, Fish-scales, Unio, Paludina
11	Clay parting	0 3	
12	Same stone as No. 10	0 4	
13	Marl	0 4	Unio
14	Stone	0 3	Turtle
15	Paludina marl	0 7	Paludina
16	Blue clay based on sand	1 4	
17	Stone	0 2	
18	Marl and sandstone	0 10	Paludina
19	Blue clay and sand laminated	2 0	
20	Greenish hard sandy rock	0 4	
21	Hard greenish marl with green specks	1 2	Paludina, Cypris, scales, &c., in a band at the
22	Clay and sands with much drift-wood	1 3	bottom
23	Hard sand rock full of remains	1 10	Wood, Cypris, Paludina, Cyclas? Fish-scales,
24	Alum clay	2 6	Palates, &c.
25	Hard brown sandy rock	0 4	Unio, Fish-scales, many Coprolites
26	Clay	0 10	
27	Similar rock to No. 25	0 4	Ditto
	Unio beds.		
28	Nodular brown earthy limestone embedded in blue clay, at times composed of Paludina	3 0	This is the equivalent of the "marble" of Purbeck, Paludina

	Character of Rock.	Thickness ft.	in.	Organic Remains.
29	Laminated clays and sands, much drift at bottom	1	0	
30	Hard sandy stone "Unio bed"	1	0	Unio, two species; some excellent specimens may be obtained
31	Laminated clay	0	3	
32	Soft brown sandy rock	0	8	Unio
33	Alum clays	1	0	
34	Hard brown sandy rock	0	6	
35	Olive clays and sands laminated (say)	2	0	
36	A sandy dirt-bed full of perished shells, resting on a line of clay	1	0	Unio, Paludina, Fish-teeth
37	Sand full of Unios	0	3	Unio
38	Yellowish-brown sandy rock	0	9	Unio
39	Ditto finer and harder	1	0	Unio and small bivalves

MIDDLE.

	Upper broken-shell limestone.			
40	Hard grey marlstone conchoidal fracture in brown sand, with narrow lines of 'beef,' (fibrous carbonate of lime)	2	6	
(41)	(Drift with flint gravel)	0	1	
42	Extremely hard grey marly rock	1	0	
43	Coarse drift	0	6	
44	Extremely hard grey marly rock	0	8	
	Sandy parting			
45	Hard limestone composed of bivalves (like Swanage paving-stone)	0	4	
46	Ditto	0	10	
47	Fine hard limestone of comminuted shells, blue towards centre	1	0	
48	Shelly parting; 1 inch beef	0	3	
49	Comminuted shell-limestone	0	4	
50	Rotten shelly earth	1	0	
51	Hard comminuted shell-limestone	2	0	
	Chief beef beds.			
52	Beef	0	2	

	Character of Rock.	Thickness ft. in.	Organic Remains.
	Chief beef beds (continued).		
53	Compressed bivalves in ribbony layers	0 10	
54	Irregular bed of extremely hard great crystalline nodules of marl, with beef, clay, shells, and limestone	2 0	
55	Limestone of comminuted shells	1 6	
	Corbula beds.		
56	Reddish-brown sand and earth	1 0	
57	Brown sandy rock of Cyrena	2 0	Crystalline bands with shells
58	Sand with rotten bivalve shells	2 0	
59	Rotten dark greenish sandy rock, with small Ostreæ and bivalves	1 0	Ostrea
60	Irregular clay and rock	2 0	
61	Extremely hard crystalline nodular rock in alum shale with shells	2 0	
62	Hard shelly rock of irregular thickness, beef	1 0	Teeth, Turtle?
63	Coarse shelly shale	1 0	
64	Band of stone composed of bivalves	0 6	
	Intermarine.		
65	Coarse brown sandy rock composed of casts of Thracia	1 2	Thracia
66	Ditto harder, fewer shells	1 6	Thracia, Modiola, Perna, Pecten, &c.
67	Ripple-marked sandstone, splitting into slabs	2 0	
68	Brown sand	1 4	
	Freshwater.		
69	Marly white rock	1 6	Cypris, shells
70	Shaly whitish cypris stone, parting of beef, sand, &c.	0 10	
(71)	(Gravel)	0 6	
72	Clay, rotten shell and beef in layers, olive-green and white	1 6	
73	Hard gray shelly limestone, with green specks, the shells not bedded	1 6	
74	Hard white marl with yellow specks, conchoidal fract.	0 6	

	Character of Rock.	Thickness ft. in.	Organic Remains.
75	Crushed bivalves	1 0	
76	White line with broken oysters, washed out of cinder	0 1	
	Cinder bed.		
77	Cinder, composed of oysters and marl	3 0	Ostrea distorta, Cardium at the bottom
78	Lower cinder of comminuted shell	2 0	
79	Beef with impressions of cracks from drying of the next bed	0 2	
	Cherty middle freshwater.		
80	Laminated clays, brown and yellow, compressed Cyclas	0 10	Cyclas
81	Purplish dirt full of shells	1 6	Cypris, Cyclas, Physa, Paludina, Planorbis, Valvata, Melanopsis, Pinna, Bones of Saurians, Turtle, Chara
82	Chert, containing the same shells, better preserved	1 4	
83	Lenticular lumps of dark chert, containing the same shells, with Chara seeds, and resting upon a layer of carbonaceous matter	0 4	Excellent for specimens of the smaller shells
84	Sand	0 3	
85	Laminated light-coloured clays and sands, somewhat indurated (shaly)	0 10	Large impressions of vegetables, branching
86	Brown clay parting	0 1	
87	Band with Cyclas	0 4	Cyclas, Physa
	Marly middle freshwater.		
88	Coarse marly limestone with yellow stains	1 6	Cypris
89	Beef and clay alternating	1 0	
90	Olive-green clay	0 10	Cypris, Hydrobia
91	Marly limestone, white and fine-grained conch. fracture	1 10	
92	Laminated yellow and brown clay	0 10	Cypris
93	Yellowish Cypris-stone	0 8	Cypris, Hydrobia

LOWER.

	Character of Rock.	Thickness ft. in.	Organic Remains.
	Marly middle freshwater (continued).		
94	Olive-green clay	0 6	
95	Marly limestone weathering into vertical splinters, with vertical stripes of yellow stain	0 10	Fucoids
96	Clay parting	0 1	
97	Pale salmon-coloured limestone of comminuted shells and Cypris	1 0	
98	Clay parting	0 6	
99	Shaly limestone	0 10	
100	Hard bluish-grey marly limestone, conch. fracture	0 1	
	Upper Insect-beds.		
101	Laminated green and brown clay parting, with carbonaceous specks	0 1	
102	Laminated calcareous marls, carbonaceous specks	0 6	Cypris Purbeckensis
103	Hard grey marls, conch. fracture	0 9	Elytra and bodies of beetles
104	Hard grey marls with carbonaceous specks occasionally large	0 6	
105	Parting of yellowish cream-coloured marl	0 2	
106	Hard cream-coloured marl with carbonaceous specks and elytra	0 6	Elytra of beetles, occasionally very abundant
107	Ditto, with no remains	0 5	
108	Ditto, softer	0 8	
109	Yellow clay passing into marlstone, carbonaceous specks and elytra	1 0	Elytra of beetles
110	Cream-coloured marlstone, carb, specks, and elytra	0 4	Elytra of beetles
	Soft-cockle beds.		
111	Olive-brown laminated clay, with bivalves and carbonaceous specks	0 4	Cypris

	Character of Rock.	Thickness	Organic Remains.
		ft. in.	
112	Yellow Cypris-stone showing the bedding	1 4	Minute Serpula
113	Dark clay	0 10	
114	Greenish grey marlstone	1 0	
115	Ochreous clay	0 4	
116	Soft oolitic-looking Cypris-stone with sandy veins	6 6	
117	Marly rock	1 6	Corbula, Cardium, small Serpula at the bottom
118	Ribbony clays and sands	0 10	A bivalve, Cypris
119	Marly stone	0 10	Small Cardium, Serpula, Modiola, Cypris, Serpula.
120	Hard crystalline rock of comminuted shells, marly at the bottom	1 4	
121	Green and brown laminated clays, polished surfaces as in slicken-slide	0 6	Cypris, carb. specks
122	Marly stone veined with Cypris, and comminuted shells	2 6	Serpula, Cypris
123	Brown laminated clay	0 4	Cypris, carb. specks
124	Hard marly rock	2 0	Leda, Modiola, &c., near the top
125	Dark laminated clay, containing a band of comminuted shells	1 6	
126	Slightly indurated Cypris-clay not laminated (grey)	0 6	Cypris, small Cardium, Serpula
127	Ditto, laminated	0 6	
128	Ditto, sandy	0 3	
129	Ditto, passing into calcareous sandstone	0 8	
130	Ribbony clays and white sandstones	4 0	
	Hard-cockle beds.		
131	Rotten limestone, composed of casts of Cardium, &c.	0 8	Cardium, Rissoa, Cypris
132	Laminated brown clay	0 3	
133	Hard marlstone, conch. fracture	1 0	Cypris
134	Hard crystalline rock of shells (quarried for)	3 6	Cardium, Cypris
135	Laminated calc. sand and soft sandy rock	3 6	

	Character of Rock.	Thickness ft.	in.	Organic Remains.
	Lower Insect-bed.			
136	Hard marly rock with streaky bedding	1	9	A chrysalis common, wings of Libellula, dipterous, hemipterous, and orthopterous insects, Elytra of beetles, carb. specks
137	Ribbon clays and sands, sometimes indurated	4	0	
138	Dense Cypris-stone (quarried)	1	6	Fish-scales
	Cypris Freestone.			
139	Ribbony clays and sands	1	6	Carbonaceous specks
140	Soft Cypris-stone (quarried)	3	0	
141	Sandy limestones shale (say)	2	0	
142	Cypris-stone (quarried)	2	0	
143	Harder ditto (quarried)	2	0	
144	Fissile white limestone shales having a bituminous smell when struck	5	0	Carbonaceous specks, Fish-scales, Cypris
145	Hardish Cypris-rock	2	6	
146	Brown clay parting	0	1	
147	Sandy limestone shales	4	0	
148	Soft white sandy rock	2	0	
149	Ditto more friable (some coarse sand occasionally)	1	0	
	Broken Bands.			
150	Cherty marl with flint at the bottom	1	3	Valvata helicoides Lymneus physoides
151	Shaly limestone	3	0	
152	Argillaceous shale of variable thickness	1	6	
153	Band of indurated rubbly shale	0	4	
154	Clay parting with thin chert	0	2	
155	Indurated calcareous mud	3	0	Cypris, Valvata helicoides, Vegetable specks disseminated
	Hard and soft Cap.			
156	Rubbly calcareous shales with some chert	1	6	
157	Chert, saccharine limestone	1	0	
158	Calcareous shales	2	0	

	Character of Rock.	Thickness		Organic Remains.
		ft.	*in.*	
159	"Portland dirt-bed"	1	0	Fossil wood
160	Band with fish	0	4	Histionotus breviceps
161	Band with Archæoniscus	0	4	Fragments of a large Archæoniscus very abundant
162	Hard cap	0	6	Cypris, Paludina
	TOTAL	190	9	
	Portland Stone.			

The published list of mollusca and crustacea from the Dorsetshire Purbecks, were increased by Professor Forbes's investigations from twelve species to eighty. Since then some remarkable discoveries have been made, chiefly in Durlestone Bay. From the 'dirt-bed' of the middle Purbecks, the stratum No. 93 of Rev. O. Fisher's Memoir, Mr. Beckles collected in a few weeks remains belonging to fourteen species of mammalia. The importance of this discovery may be judged from the fact, that the entire number of fossil mammalia previously known from all the beds, older than the tertiaries, were but five; not one species having been recorded between the year 1818 and 1854. Further additions may be expected to the list, as the area over which Mr. Beckles' operations were conducted did not exceed five hundred square yards.*

The Dorsetshire County Museum possesses the fine collection of Purbeck fossils made by Mr. Wilcox of Swanage, which, with additions made by the Revs. Osmond Fisher and P. B. Brodie, and others, forms probably the best collection of the fossils of the Purbeck formation that exists in any museum. The specimens include mammalian remains, turtles, fishes, insects, &c., of which many are rare, and some unique. The upper cases of the Museum of Practical Geology in Jermyn-Street (London)

* For a description of these interesting discoveries see Supplement to the Fifth Edition of Sir C. Lyell's 'Manual of Geology,' 1857; also 'Fossil Reptilian and Mammalian Remains from the Purbecks,' by Professor Owen, 'Geo. Pro.' vol. x. p. 420.

contain many good specimens of insects. The greater portion of these, together with those in the Dorchester Museum, are figured and described by Mr. Westwood in a paper entitled 'Contributions to Fossil Entomology,' 'Geo. Pro.' vol. x. page 378.

The same volume, page 475, contains a communication by the Rev. P. B. Brodie, M.A., F.G.S., (author of several valuable contributions to the Geology of Dorsetshire), 'On the Insect Beds of the Purbeck Formations of Wiltshire and Dorsetshire.'

Chalbury, Sutton.—Three miles north of Weymouth, there are numerous sections of the Purbeck and Portland series. The first quarry or cutting, near the boiling rock,* is in a convenient situation for working, but from the inferior quality of the stone, it has been abandoned. A little farther up the hill on the right, stone is quarried both for building and lime-burning. Portions of the Portland stone are here white like chalk. Their similarity to the latter formation is further strengthened by the presence of large coated flints, similar to those occurring in the chalk. The stone is fine in texture, and breaks with a conchoidal fracture. From the absence of the more 'oolitic' strata, and the scarcity of fossil remains, the beds are not easily made out. The top strata, which belong to the lower Purbecks, are much shattered, partly perhaps from exposure. The dirt-bed is not distinguishable, and its presence might be questioned, but for some fragments of fossil wood which are occasionally met with.

The passage of the Purbeck strata into those of Portland is not distinct, though the latter is determinable by means of one or two well-known fossils. No open fissures occur here as in the Isle of Portland. Crystallized carbonate of lime fills cracks and other interstices of the stone, which under similar circumstances in Portland are coated with stalactite. Among the few fossils to be found are

* So called from its being the springhead of the stream which for many years supplied the town of Weymouth with water. The new company obtains its supply from Preston.

Ammonites giganteus, *Trigonia incurva*, *Myacites Jurasii*, *Pleurotomaria rugata*, *Crustacean* impressions, &c.

In another quarry at Loddon, two hundred yards on the west, there is a section of the middle Purbecks, which appear to agree with that portion of the series displayed in the Ridgway cutting. The strata are, however, horizontal, and not highly inclined, as at the last-named locality.

A new species of fish, *Megalurus Damoni*, Egerton, (ninth Decade of the Geological Survey, Plate 8, 1858), is found here. *Scales*, *palates*, and other fish remains are sparingly scattered throughout, with *cyclades* in great abundance.

HASTINGS SANDS.

The Hastings Sands form a portion of the Wealden formation, which is so named from its having been first studied in the counties of Kent, Surrey, and Sussex (called the Weald), and although of small geographical area or extent, it is of considerable geological interest, as evidencing the existence of dry land after and before its submergence. Mr. C. Weston was the first to establish the presence of this member of the Wealden at Ridgway,* where, in a cutting on the south side of the tunnel, variously coloured clays are exhibited characteristic of this formation. In a stiff blue clay near the base of the series, and just above the Purbecks, portions of colossal Dinosaurian herbivorous reptiles have been found, referred to the genus *Iguanodon*; *Hylæosaurus* and *Megalosaurus*, also the stems of a peculiar plant, *Clathraria Lyellii*. Some of these remains are deposited in the County Museum in Dorchester.

The Hastings Sands and Weald clay are also present on both sides of Lulworth Cove, where they partake of the disturbed character of that locality, and occupy a nearly vertical position (see page 102, Fig. 44).

Their prevailing colour is a dull yellow, with occasional bands of a darker hue. The lower portion contains much

* 'Geo. Pro.' vol. iv. p. 250.

iron, and its deep rusty colour forms a striking contrast to the main mass of white chalk cliffs on the north side of the Cove. A few casts of fossils are found in the nodules which occur towards the upper part. On the high land a little west of Lulworth, the Hastings Sands form the face of the upper part of the cliff.

NOTE.—Throughout the entire section of the Wealden on the Sussex coast, an extent of 18 miles, Mr. Beckles detected a series of foot-prints of great dimensions, and from their general uniformity of character, position, and direction, he draws the following inferences:—

First. That *bipedal* animals having tridactyle feet of enormous proportions lived during the Wealden epoch.

Secondly. That the alternation of right and left footsteps proves the animals to have been biped.

Thirdly. The numbers and positions of the toes seem to ally these animals to birds; while, however, it may be regarded as undetermined whether these gigantic creatures were birds, or reptiles with ornithic characters.—'Geo. Pro.' vol. x. p. 462.

The *Brontozoum giganteum*, or colossal biped that produced the largest triassic footprints, is supposed to have been four or five times the size of the large African ostrich; yet the superficial measure of this gigantic foot could not have been one-third of that of the stupendous Wealden biped, as I obtained a specimen measuring 27 inches in length, by nearly 24 inches in breadth, with a stride of 42 inches.—*Ibid.*

Mr. Beckles, who has given his attention to this class of fossil remains, further observes, that there is in the Geological Society's collection a large slab of Purbeck limestone, the surface of which is shaly, and covered with coarse fucoidal (?) markings. In this shaly portion are two large, trifid, pachytactylus foot-marks, resembling those from the Wealden, each measuring twelve inches in length. The occurrence of these singular memorials may therefore be looked for in the same formations of this district.

UPPER GREENSAND.

Characteristic Fossils.

Fig. 47

Fig. 48

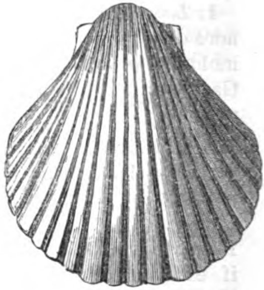


Fig. 49

Fig. 47. *Exogyra conica.* Nat. size.
Fig. 48. *Vermicularia concava.* do.
Fig. 49. *Pecten quadricostatus.* Reduced.
From the Upper Greensand, Osmington Mills, and White Nore.

The above term, though applicable to the greensand of this district, is not always so appropriate, since in some places it is not green, while in others it is not of a sandy nature. Usually it is composed of a siliceous or siliceo-calcareous sand, mixed with minute spangles of mica, and specks of green earth* (Glauconite), from which last it derives its distinguishing colour. In the absence of the latter substance it is yellowish or grey. This formation generally attains a considerable elevation, being near Warminster 800 feet above the level of the sea, Blackdown Hills, near Lyme Regis, 817, Charmouth 800 feet: White Nore is its highest point near Weymouth.

Immediately underlying and conformable to the Chalk, and having the same dip to the north, of about 20°, it appears to follow the course of that formation through Chaldon, Holworth, Bincombe, &c., to its western termination

* 'These green particles being the same as those in the Portland sand, and consist principally of silica, and protoxide of iron, with 10 per cent. of potash and 10 per cent. of alumina.'—'Geo. Trans.' vol. ii. 2nd series, p. 108

at Abbotsbury, small outlying patches being occasionally visible throughout that distance. Where the *whole* of the Greensand series is present, the section is as follows:—

1. *Lower Greensand.* This member of the group is not here distinguishable, though Dr. Fitton thinks it may be included in a general mass of sand and clay under the Gault, which, on the east side of Lulworth Cove, he reckons at 120 feet in thickness.*

2. *Gault.* This formation is considered by Dr. Fitton to be present at Lulworth Cove also, but for the most part concealed by a bed of chalk rubble. The Rev. Osmond Fisher, in his description of the strata at White Nore,† includes the Gault amongst the strata there, which, if established, we have within an area of 3 miles, the Upper Greensand resting successively on formations of five different ages, viz., at the White Nore on the Gault, Upton Valley on the Purbeck, Upton Hill towards the coast on Portland stone, Osmington Mills on the Hastings sand, and also on the Kimeridge clay, an excellent illustration of unconformable stratification. In this instance the older rocks have been raised, so that the plane of the Greensand, the stratum above, rests upon their edges. In this way it is easy to see that, over a very small area, a series of older strata may be brought in contact with one of a much later period; the Greensand being deposited after the strata below had been thrown out of their horizontal position.

3. *Upper Greensand.* To this part of the series is referred the Greensand at the following points.

White Nore Cliff.—A fine section estimated at 100 feet in thickness,‡ and interspersed with layers of large cherty nodules.§

* Dr. Fitton, 'On the Strata below the Chalk,' p. 216.

† 'On the Purbeck Strata of Dorsetshire,' vide section, p. 2.

‡ Dr. Buckland and De la Beche, p. 9.

§ To which are equivalent the concretions of the Whetstone pits of the Upper Greensand of Blackdown in Devonshire, from which the scythe-stones are prepared.

FOSSILS from the GREENSAND, WHITE NORE, and OSMINGTON MILLS.—At the latter locality it forms the crest of the hill overlooking the romantic little village of Osmington Mills, and where we find the following fossils:—

Shark's teeth.
Cardiaster suborbicularis, Defr.
Pecten quadricostatus, Sow.
 „ *quinquecostatus*, Sow.
 „ *a small species.*
 „ *asper*, Lam.
 „ *orbicularis*, Sow.
Exogyra columba, Lam.
 „ *conica*, Sow.
Ostrea (?).
Gryphœa vesiculosa, Sow.
Vermicularia (Vermetus) *concava*, Sow.
Serpulœ.
Stems of *Siphoniœ.*

At Abbotsbury, there is an escarpment of Greensand of considerable thickness, and containing fossils similar to the above.

Notwithstanding the small number of species referred to the Greensand of this district, it is in some places distinguished both for the number as well as for the beauty of its fossil shells, 150 species being recorded from the Blackdown Hills alone.

Like the Chalk, the Greensand of Dorsetshire presents many high and insulated masses, intersected by valleys and plains.

As the Upper Greensand passes insensibly into marly chalk, so the latter graduates into the lower chalk. The Chloritic marl was formerly assigned to the Greensand series, but is now included with the Chalk. At the White Nore it forms the base of that formation. It is generally of a grey or pale yellow tint, occasionally greenish, arising from particles of green earth (Glauconite), which assimilates it to the beds of Greensand

CHLORITIC MARL. Characteristic Fossils.

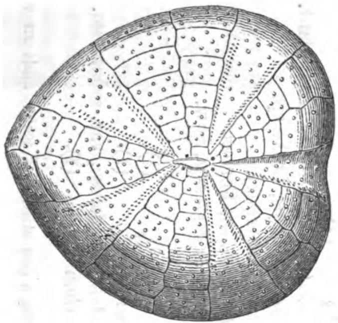


Fig. 50

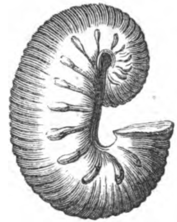


Fig. 51

Fig. 52

Fig. 53

Fig. 50.	*Holaster subglobosa*, Dixon.	Nat. size.
Fig. 51.	*Scaphites æqualis*, Sow.	do.
Fig. 52.	*Turrilites costatus*, Lam.	do.
Fig. 53.	*Ammonites varians*, Sow.	do.

All from the Chloritic Marl of White Nore, near Weymouth.

beneath. Small grains of white quartz characterize this stratum, and impart to it a degree of hardness sufficient for architectural uses. It occupies a naturally useful position in chalk districts, as from its tenacious character it retains the water which percolates through the more porous chalk,* and if, from some exceptional cause, water is not thrown out by this bed, it is generally found necessary to pass through the sands beneath to a considerable depth.

The chloritic marl is remarkable not only for the number of its organic remains, but for their interesting and singular character, many of which are peculiar to this formation.

FOSSILS FROM THE CHLORITIC MARL OF WHITE NORE, generally from the surfaces of large blocks on the shore, recently dislodged from the cliffs above.

Fish-teeth and *Coprolites*.
Ammonites varians, Sow.
"
"
Nautilus lævigatus, D'Orb.
Turrilites costatus, Lam.
Scaphites æqualis, Sow.
Hamites (?).
Baculites (?).
Holaster subglobosa, Dixon. Abundant.
Discoidea subuculus, Leske sp.
Micraster (*Spatangus*).
Galerites castanea, Forbes.
Pleurotomaria depressus, Sow.
"
Natica (?).
Avellana (?).
Terebratula semiglobosa, var. *subundata*.
Unicardium (?).

* At Lulworth Cove, a fine stream of water finds an outlet from the base of the chalk.

At Lulworth on the coast the chloritic marl yields the same species, though more sparingly.

Small patches of this formation appear at intervals towards the summit of the chalk ridge from Bincombe westward.

CHALK.

1. Chalk with layers of flint.
2. „ with a few scattered flints.

This formation, so characteristic of the south and east coasts of England, finds its termination in the cliffs of Dorsetshire, forming the most elevated portion of the range of hills east of Weymouth Bay.

Pennant, in describing the range and extent of the English chalk, denominates that portion which spreads over the counties of Wilts and Hants as the centre and source whence it diverges into several branches. Mr. Conybeare * gives a figure of the letter K placed slanting, with the lower part of its stem bent inwards, as represening the direction of these various chains, one of which, indicated by the lower arm, is thrown off from the south-east angle of the central mass, passes to the sea at Beachey Head, and thence south through the Isle of Wight to its termination at White Nore. From the latter point it proceeds inland, as may be seen at Ower Moigne, where the turf and surface soil having been removed from the chalk they covered, a colossal figure in white of George III., on horseback, is visible on the slope of the hill, facing Weymouth.† Some remarkable features of this formation

* 'Outlines of the Geology of England and Wales,' p. 84.

† It measures in height 174 feet.

NOTE.—Chalk in its pure state is composed of about equal parts of carbonic acid and lime. It is not always white: in the wolds of Lincolnshire, it consists of red and white layers each lying in regular strata, and at Hunstanton in Yorkshire, it occurs as a hard red stone, which is sometimes ground, and made into a red paint.

In parts of N. Germany, the only white chalk rocks are those of the tertiary age.

In the Island of Raghlin in Ireland, the chalk is traversed by Basalt, are displayed on this coast, where the chalk strata present every degree of inclination, until they assume an actual vertical position. At Bat's Corner, west of Lulworth Cove, the strata of chalk with layers of flint are nearly vertical, (see Plate, Fig. 54.) Half a mile on the west it is horizontal, these two points being united by a set of curved strata. At other points, east and west of Lulworth, the chalk is also curiously contorted, while at Handfast Point it is almost vertical;* a condition of the strata that might have been caused either by subsidence or upheaval. The presence of any Plutonic or metamorphic † rocks would refer it to the latter agency. Clayey strata lie beneath, and a sapping of these would produce all the visible effects.

Mr. Webster remarks that the vertical beds of chalk are harder than the horizontal beds.

The thickness of the chalk at Blackdown, near Weymouth, is 800 feet.‡

High hills and absence of trees characterize chalk dis-

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and converted by it into a hard crystalline limestone, adapted for building. Several old English churches and abbeys are built of hard chalk. Near Dresden, the equivalent to the English chalk is a hard siliceous sandstone.

In the vicinity of Moscow, the carboniferous limestone is a white chalk, containing fossils of that older formation.

* On the flanks of the Hartz mountains in Northern Germany, the chalk not only occupies a vertical position, but is sometimes even inverted. Second edit. of P. Johnstone's 'Physical Atlas,' p. 14.

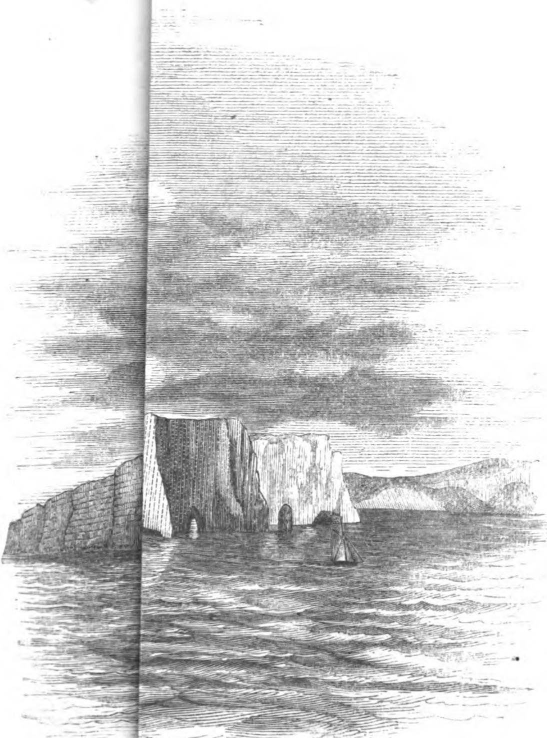
† *Plutonic* rocks; granite, and other rocks that have consolidated from a melted state: *Metamorphic* rocks, those which have been altered by heat or Plutonic action.

‡ The following are among the highest summits of the chalk hills in England:—

Coast of Norfolk	600 feet
Wilton Beacon, Coast of Yorkshire . .	809 ,,
Wendover Hill	904 ,,
Butser Hill, Hants	917 ,,
Combe Hill, Wilts—its highest elevation in England	1011

(Conybeare's 'Outlines of Geology,' p. 84, and 'Geo. Trans.' new series, vol. ii. part 1, p. 126).

[The



COAST Furved strata of the chalk with flint layers.

tricts. Organic remains, though generally numerous, are are not so in this neighbourhood, notwithstanding the extent of the formation and the large surface here exposed.*

LIST OF FOSSILS FROM THE CHALK AT WHITE NORE.

Teeth of fish.
Holaster (*Ananchytes*) *ovatus*, Forbes. G. S. Decade, 4 t. 6.
,, (*Spatangus*) *planus*, Mant. Geol. Sus. t. 17, fig. 19.
Micraster rostratus, Mant. Eeo. Sus. t. 17, fig. 10.
Galerites abbreviatus, Lam.
Salenia (?)
Pecten quinquecostatus, Sow.

The chalk occupies a remarkable position on the summit of the Savoy Alps, 10,000 feet above the level of the sea.

Opinions are divided on the subject of the origin of chalk. Some supposing it was formed by chemical action, some by mechanical action, and deposited as an ordinary mud; others that it consists of an aggregation of microscopic organized forms which lived in that ancient ocean of which the chalk area was the bed. Experiments connected with the laying of the Atlantic Submarine Telegraphic Cable indicate, that the bottom of that ocean is a mass of minute shells. See also the following extract from Maury's 'Physical Geography of the Sea,' second edition, p. 254. 'All these deep-sea soundings (conducted by Lieut. Berryman of the United States Surveying Expedition) are filled with microscopic shells, not a particle of sand or gravel exists in them. They are chiefly made up of perfect little calcareous shells, *Foraminifera*, and contain also a small number of *Diatomacea*.'

* The following divisions of the soils is given in the Agricultural Report of the County of Dorset by Stevenson:—

Chalk .	160,759	acres.
Sand .	85,157	,,
Loam .	37,746	,,
Gravel .	59,894	,,
Cornbrash.	29,700	,,
Clay .	117,331	,,
Miscellaneous	13,427	,,

Total 504,014, exclusive of rivers, roads, towns, &c.

Inoceramus Brongniarti, Sow.
Lima (?)
Terebratula semiglobosa, Sow.
„ var. *subundata.*
„ *carnea*, Sow.
Rhynchoncella plicatilis, Sow.
„ *pectita.*
Belemnitella (*Belemnites*) *mucronata*, Mant.

TERTIARY SERIES.

Under this division were formerly included all strata deposited subsequently to the Chalk.* No department of Geology has of late years received more attention and yielded more interesting results than the numerous formations embraced in this period. Strata once regarded as contemporaneous are found to have been formed at widely separated intervals. There is, though, more difficulty in establishing the relative age of the tertiaries than of the older rocks. The classification now accepted is founded almost exclusively upon their fossil remains, it being a safe course to consider those strata the most recent, the organic remains of which bear the closest resemblance to living forms. Existing species first make their appearance at the commencement of the tertiary era.

As the elder strata predominated in the north of England, so the south and east are covered with tertiary deposits. In England the tertiary strata here finds their westerly termination, passing to the east through Corfe, Poole, &c., to Studland and the well-known *Barton Clay Cliffs* (Middle Eocene) in Hampshire. They reappear in the Isle of Wight, where they present a singular and highly interesting condition in the vertical and many-coloured sands of Alum Bay.

* The upper chalk in Great Britain, but on the Continent the 'Maestricht' beds form the uppermost part of the formation : the latter are not represented in Great Britain.

The sterile plains and heathy commons on the borders of Dorset and Hants formed part of the bed of a sea that existed during the tertiary period.

PLASTIC CLAY,

OR, WOOLWICH AND READING SERIES—(Lower Eocene).

The surface of the Chalk is occasionally of the most irregular character: in some places it has been entirely removed, in others it is scooped into furrows, basins, and variously-shaped cavities* filled with tertiary deposits, of which the lowest is the Plastic Clay, so named from the economic purposes to which some of its beds are frequently applied. Several outlying patches occur in the immediate neighbourhood under consideration; and to the north-east of Weymouth there are some extensive and valuable deposits belonging to this formation.

These clays, of different colours, white, grey, yellow, and red, are of different degrees of purity, and according to their qualities are described as brick-clay, potters'-clay, and pipe-clay. In the park at East Lulworth, variegated clays rest on the Chalk.

Bincombe Heath.—In the above division of tertiaries are included those accumulations of flint, gravel, and sand which on the summit of Bincombe Heath occupy deep cavities, and were lodged in their present recesses when that area was submerged beneath the sea. They consist of—

1. Coarse and crystalline sand, with large flints and cherty masses, the latter containing casts of *Echini*, *Terebratulæ*, and other fossil shells from the cretaceous formation.

2. Chalk flints, mixed with more or less of sand, and gravel, with rolled flint pebbles.

* London, Paris, and Vienna are built on formations of lower tertiary age, which were deposited in large basins or concave areas of which the Chalk formed the then sea-bottom and shore.

3. At the highest point the material is of smaller size, with a large proportion of fragments of milk-white quartz, shivered into smaller fragments and partially rolled. In some spots the small pebbles are contained in a matrix of black earth. The locality has long been famous for a fine white sand, much valued for house building. These deposits, which have been largely worked during the construction of the adjacent railway, are repeated at Waddon and Blackdown to the west, and over a larger surface on the north-east of Weymouth.

BAGSHOT SERIES.

(Middle Eocene.)

The clays at Corfe were considered by the late Mr Trimmer to belong to the lower part of this series,* and his views have been adopted by the Geological Survey (Vertical Section No. 25, and Horizontal Section No. 56, illustrative of Map No. 10). The Dorchester and Southampton Railroad through Moreton and Wool passes over these deposits. The clay-pits are three miles from Wareham, and near to the beautiful ruins of Corfe Castle.†

* 'Geo. Pro.' vol. ix. p. 63.

† The great county historian, Hutchins, states that King Edgar was probably the founder of this magnificent structure, though the first mention made of it in our histories is A.D. 978, upon occasion of the barbarous murder of Edward, King of the West Saxons, committed here by his mother-in-law, Elfrida. The castle was the residence of the West Saxon Princes, when they came to the Isle of Purbeck to hunt. It was also the place of confinement for persons of the highest rank. Here King John kept the regalia of the crown.

In the Civil War it was one of the last places in England that held out for the king. After a siege which lasted 48 days, it was taken Feb. 26, 1645, when it was plundered, undermined, and reduced to its present state of ruin. The route to Corfe Castle is by the South-Western Railway from Weymouth to Wareham.

Section of one of the clay-pits between Corfe and Wareham.*

Bed of lignite, about	10 feet.
Grey clay with carbonized leaves	2 "
Yellow sand with leaves	2 "
Ferruginous band, a few inches	
Whitesand, about	30 "
Pipe-clay	11 to 14 "
Total	58 feet.

The finer quality of the pipe-clay is used in the manufacture of china and earthenware; the inferior quality for the manufacture of alum.

The following analysis of the Corfe clay, by Professor Way, is extracted from a paper by J. Trimmer, Esq., F.G.S., in the 'Journal of the Royal Agricultural Society of England,' vol. xvi. part 1.

	White Clay.	Black Clay.
Silica	65·49	72·23
Alumina	21·28	23·25
Oxides of iron	1·26	2·54
Alkalies and alkaline earths	7·25	1·78
Sulphate of lime	4·72	0·00
	100·00	99·80

Well-preserved leaves of many kinds of plants may be collected in the Corfe clay-pits. Also insect remains which have been figured and described by Mr. Westwood.—'Geo. Pro.,' vol. x. p. 381.

BONE CAVERNS.

(Newer Pliocene period.)

Quarrying operations in the Island of Portland frequently lead to the discovery of accumulations of bones

* 'Purbeck Papers,' 1852. Rev. Mr. Austen.

belonging to extinct quadrupeds, mingled with others of existing species. In the year 1840, a heap equal to several cartloads, was removed from a quarry on the north-east side of the island. A selection was made from these bones, and deposited in the Museum of the Weymouth Institute. Among others the following species were identified—

Head and bones of a very large boar.

Bones of a large species of ox.

Skulls, antlers, and other bones of a deer, with remains of a horse, wolf, sheep, and of other numerous smaller animals.

Teeth of an extinct species of native horse are often met with.

From remains of the above animals being discovered in proximity to human bones (it is said that both kinds have been found together), but I have never been able either by personal investigation, or from the testimony of others, to obtain evidence that would lead me to such a conclusion. The latter are interred remains,* and found a few feet beneath the surface in the rubble bed, though a stray bone or two may find its way down a fissure where the bones of other animals may have been deposited.

These fissure-bones, though not in a fossilized state, are nevertheless of great antiquity, being lighter and more fragile than recent bones, though still containing a portion of animal matter.† Their preservation in caves and fissures is in

* Some of these bodies, judging from associated relics, were Roman; others, too, may be referred to the time of the Civil Wars, when the Island of Portland was the scene of several contests between the Parliamentary and Royalist armies.

'In the Autumn of 1851, in the Isle of Portland, sepulchral remains of the Romano-British period were discovered, including a stone coffin which contained the remains of two persons, supposed to have been male and female.' ('Archæological Journal,' vol. x. p. 61.)

† The tongue, when applied to ancient bones found in caves and fissures, readily adheres; not so in the case of human and other bones of later date, which retain too much animal matter or gluten to admit of this test.

[Fossil

great measure due to the stalagmitic deposits which cover the ground and fill up the interstices around them, thus protecting the bones from the variations of temperature, an exposure to which would soon decompose them. Though generally removed before the conditions under which they are deposited can be examined by those who are aware of the points on which information is most important and desirable, the quarrymen agree in stating that they are found in, or near a gully (fissure) which has no communication with the surface immediately above. The question 'how came they in this situation?' may perhaps receive a solution in one of the following conjectures.*

1st. 'That these caverns and fissures afforded recesses that were the resort of beasts of prey, the bones being the remains of animals that had been devoured by them for their food.' At Kirkdale cave the bones have the appearance of being broken and gnawed by the teeth of hyænas and other carnivorous animals. The bones, how-

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Fossil bones found in ordinary strata will adhere in consequence of the loss of animal gluten, and the substitution of a mineral substance, or the residue of their carbonate of lime.

The results of some analysis made by Mr. Way, on recent and fossil bones, are given in the Proceedings of the Ashmolean Society of Oxford (1844). All the bones examined contained fluorine; but the carbonate of lime in the fossil exceeded that contained in the bones of recently killed animals. The excess being considered due to infiltration. Some of the results of the analysis were as follows:—

	Organic matter per cent.	Carbonate of lime per cent.
Astralagus of ox recently killed	33·29	4·91
Ditto „ Kirkdale cave	29·19	9·86

* Applied by Dr. Buckland to a vast quantity of bones found in caves at Kirkdale in Yorkshire, and Kent's Hole, Torquay. These discoveries formed the chief materials of the 'Reliquiæ Diluvianæ,' which contain a description of all the bone caverns and fissures known up to the time of its publication, and before the discovery of bones in the Portland fissures. The tendency and aim of the work being the attestation of the action of an universal deluge.

ever, from the Portland fissures present no such appearance.

2nd. 'That the animals spontaneously entered the place in which they are found, or had fled to it as a refuge from some general convulsion.' To this it may be said that, with regard to the larger animals, the Portland fissures are not of sufficient width to admit of this explanation. Yet they might have communicated with some larger openings or approaches, all traces of which have since disappeared.

3rd. 'That the bones were those of animals that had fallen into the open fissures from above.'

In Duncombe Park, Helmsley, and in Monmouthshire, Glamorganshire, and other limestone districts, such open fissures form a trap to the animals that roam there. In Portland the fissures do not reach the surface, nor is there evidence that they have done so within the Geological period to which these deposits are referred.

4th. That they are the bones of animals drowned and drifted into their positions by the waters of a flood.

When cave—or fissure—bones are mingled with loam and gravel, it may be inferred that they were so lodged. In the absence of any violent inundation, subterranean streams may have had something to do with the bringing together of these accumulations. Although of the four hypotheses above given, the last appears to be the most probable origin of the Portland fissure-bones. It must not though be overlooked that the face of the country has been greatly changed since these animals found in this part of Great Britain the food, range, and other conditions most necessary to their existence.

The period when the bones found in caverns and fissures were deposited has not not yet been determined. In some instances the bones of the rhinoceros, hippopotamus, tiger, bear, lion, and other animals of the drift period, have been found mingled with human remains. Among the most recent of these explorations are those that have been made in caverns in Palermo and at Brixham, where flint implements in hard concretionary deposits are found associated with the bones of extinct quadrupeds. Still, in the opinion of several of our most distinguished geologists, none of these cavern accumulations necessarily prove man to have coexisted with all these animals. Having an intimate relation with the above are the recently announced discoveries in the valley of Picardy in France, where worked flints (celts) are found in the 'drift,' or old alluvium, and which have given rise to a wide-spread discussion,—'Was man among the mammoths?' The 'drift,' as has been already described, is composed of loam, sand, gravel, flints, and other materials washed out of pre-existing strata, but the period when it was supposed to have been deposited or accumulated over its present area is still undetermined, though, previous to the above discoveries, the evidence was in favour of a very ancient or pre-historic origin. Some consider the relics referred to as natural productions, and thus the difficulties of the case would be disposed of; but the question does not admit of such a solution. The flints, though of rude workmanship, are as designedly shaped, and bear the same evidence of human fabrication, as the celts and other flint weapons that are found in the British tumuli. As the subject is just now engaging a great deal of attention, a brief account of the situation and contents of the beds which have furnished these flint weapons may not be out of place, particularly as deposits of a similar nature to those of Picardy occur in this neighbourhood.

The geological features of the district are very extensive beds of peat on a level with the Somme, the higher ground being of chalk, which at intervals is capped with gravel-beds, sand, loam, and clay. The best section I saw was one mile south of Amiens, immediately off the main road, and near to St. Acheul, a suburb of Amiens.

Here a large surface is opened for brickmaking; and in one of the quarries the following section is exposed:—

Superficial or vegetable soil, none.

1. Ten or more feet of brown loam, containing human bones, old coins, nails, and other worked iron.

2. Two feet of gravel and small pebbles with a slight mixture of whitish sand.

3. Six feet of fine white marly sand with recent shells and unfossilized bones and teeth of mammalia.

4. Ten feet; a loose incohesive mass of gravel and subangular flints of all sizes held in a matrix of highly crystalline white sand, containing teeth and bones (waterworn), said to belong to the elephant, horse, deer, and ox, together with shells and echinidæ from the Chalk. It is in this deposit, which is from 60 to 80 feet above the level of the Somme, that the worked flints are found in such numbers. Stone beads I observed were very numerous.*

The significance of the discoveries at Amiens and Abbeville consists in the presence of imbedded human remains, so far beneath the surface, and in a deposit hitherto regarded as of very great antiquity.

Some would push back the date of the creation of man to agree with their conclusions from these discoveries; but further investigations will no doubt dispose of this, as it has of other apparent discrepancies between the records of Scripture and those of science.

* These singular relics are fossils (*Lunulites*) common to the Chalk formation. In their natural state they are small spherical bodies, with a small hole on the under side. In the Amiens drift the hole passes through the specimen, so as to allow of their being strung. It should, however, be observed, that in some of the examples found in the latter locality the openings are not throughout; and it has been suggested that after all they may be simply specimens that have been reduced by attrition.

The character of these organic bodies are now undergoing investigation, and it is proposed to place them in the order of Foraminifera.

POST TERTIARY.

MAMMALIFEROUS DEPOSITS, OR ELEPHANTINE PERIOD.

Characteristic Fossil.

Fig. 55.

Molar Tooth of *Elephas primigenius.* Blumenbach.* (Mammoth.)

River Bed, near Radipole Church.—With deposits of clay, loam, gravel, &c., not occurring in stratified order, but as superficial and irregular accumulations, are associated the remains of animals supposed to have become extinct anterior to the human period, and of others that survived to the age of tradition, and have since been extirpated in England. Of these, the most generally distributed is the fossil elephant or mammoth, of which there is an entire skeleton in the Imperial Museum of St. Petersburg, having a part of the skin and eyeball still preserved, taken from

* Though the Elephas primigenius was preceded in Europe by other species, *Elephas priscus*, and *Elephas meriodalis*, Prof. Owen states, that they do not appear to have gone northward beyond temperate latitudes, (Palæontology, by Richard Owen, F.R.S., p. 364,) and that all the elephant remains hitherto discovered in Great Britain are referable to the one species, *E. primigenius.* 'Dr. Falconer considers that several species are found in this country.' 'Geo. Pro.,' vol. iii. p. 307.

the frozen soil in Siberia.* Numerous teeth and bones of this huge animal have at various times been dug out of the river-bed at Radipole, in a deposit of angular flint, gravel, and debris, derived from local strata, and containing drift-wood, hazel-nuts, &c. Also from the following places: Chesil bank, off Abbotsbury, washed up from the sea; from gravel beds on the grounds of Lord Eldon, at Encombe, near Kimeridge; lately in the Island of Portland, at an elevation of 350 feet above the level of the adjacent sea. Mr. Neale, of the convict establishment, has in his possession a tusk and some grinders dug out during the quarrying operations.

NORTHERN DRIFT—BOULDER FORMATION.

(Newer Pliocene Period).

The northern or glacial drift, which at intervals has overspread a large surface of Great Britain and the Continent of Europe, does not extend to Dorsetshire, hence those unstratified beds composed of loam, gravel, flints, and other remains derived from strata of various ages (without fossils, excepting what may have been washed in from the older rocks), must be considered as deposited by local causes, in contradistinction to the great northern

* These Mammoth bones were known to early English writers, who considered them to be the remains of giants. At a more remote period, they were conjectured to be bones of the fallen angels.

Judging from the numerous and widely-distributed remains of the E. primigenius, this animal must have roamed in considerable numbers over Great Britain, that part of Europe now forming France, Italy, and Germany, where they appear to have lived and died through successive generations. On the coast of Norfolk alone the teeth found within the last thirty years have been stated to belong to 500 different individuals. Their extinction is supposed to have followed the epoch during which Great Britain was severed from the Continent, to which their migration became no longer possible, and consequently, their means of subsistence became greatly reduced. The intensely cold climate, which for a time prevailed in Europe, is supposed to have contributed to their extinction, (certain species of shells, that now only exist in the northern seas being found associated with the elephant remains).

drift, the source of which is connected with the glacial phenomena of northern origin. The boulder rocks of this period, derived from the high land of Scandinavia and North of Russia, have been carried southward over extensive tracts in Russia, Poland, and the plains of Germany, and also in parts of Scotland and the coast of Yorkshire. They are found to increase in numbers and in bulk, as they approach the rocks from whence they were detached. They form no part of the Geology of the south-west part of Great Britain, and are only noticed to show the relation of this period to that which succeeded to it.

CHALK FLINTS AND BRECCIA.

Cavities in the Chalk filled with flints washed out of its own mass, are not unfrequent, and of such there are examples at Came Down, and the summit of White Nore.

They are also found in other situations, resting on formations of various ages. In a deposit of yellow loam, covering the Coral Rag, east of Radcliff Point, unrolled flints from the Chalk are abundant in some places, forming a considerable proportion of the whole mass. The same kind of deposit may be observed in several spots on this part of the coast, all of which are referable to a very recent geological period. Besides these loose flints, others are imbedded and cemented in a coarse siliceous sand, forming masses of great solidity. These conglomerates or *Breccias* are like the pudding-stones, which characterise the Geology of Hertfordshire—excepting that those of the latter district are composed of water-worn flints. The Breccias are found scattered over and adjacent to the Chalk. In the villages of Portisham and Abbotsbury they lie about in great abundance, and at West Lulworth may be seen built into the walls on the main road leading from the cove. As their bulk and indurated character prevented their dispersion during the violent changes which have swept lighter materials from the surface, so has it since preserved them from destruction by human agency. Indeed, they are of such impenetrable hardness as only to be broken by some mechanical power. The flints which enter into the composition of these conglomerates were probably derived either from the chalk which once formed a continuous stratum over their present site, or they are the consolidated portions of the sands and sand-stones of the Plastic clay series, and it is evident how a current sufficient to dissolve and transport the soft matrix of either of these formations, and even equal to effect accumulations of loose flints, might be inadequate to the removal of such large masses.

SANDSTONE BOULDERS—DRUID STONES—GREY-WETHER STONES—SARSEN STONES.*

Blocks of sand-stone, the wrecks of former strata, probably coextensive with the Chalk, and similar to those of the Calcareous grit; the sand, or other soft matrix in which they were imbedded, having been swept away by aqueous action. Though the greywether stones are of tertiary origin, their insulated condition must be referred to diluvial† agency, acting during a geological period

* The presence of similar concretions on the opposite coast of France, in the cliffs of St. Marguerite, near Dieppe, is so distinct as to leave little doubt that it is a prolongation of the same stratum which supplied the Druidical sandstone, of Great Britain. 'Geo. Pro.,' vol. ix. p. 129.

† Diluvial (from *diluvium*, deluge) is a term often indefinitely applied to deposits, supposed to have been formed by the waters of the general Deluge, such as marine shells, remote from the sea, or on elevated districts, blocks of stone detached from their parent bed, and lodged far from their original site, accumulations of loam and gravel, bones in caverns, and fissures, &c.

At a later period many of these conditions, being traceable to other causes, beds of gravel and cave-bones were supposed to be the only visible effects of that great catastrophe. But subsequent investigations have determined even these to be of different ages. Though the Deluge must have produced considerable superficial changes, yet to define what these were involves a precision not attempted by Modern Geologists. Diluvial agency is now restricted to those superficial deposits, distinct from the present, though immediately preceding causes now in operation.

In Wilts these boulders constitute the large masses which form the pillars and circles of the Druidical Temples at Abury and Stonehenge. In this neighbourhood they have been applied to similar purposes. Half a mile west of Winterborne, on the road to Bridport, stands the remains of a British Temple, consisting of a circle formed by nine stones, enclosing an area thirty feet in diameter; and within a mile from this there are the remains of other temples: three miles west of Winterborne, and one mile north of Abbotsbury, stands a Cromlech, the only one in the county. In a field adjoining the road from Weymouth to Osmington, near to the village of Little Maine, there is another cluster of Druid stones in sands, which rest immediately on the Chalk.* Besides these, insulated blocks of large dimensions appear in situations where it is difficult to suppose any mechanical power known to the ancient Britons could have placed them. One on the slope and near the top of the hill, that overhangs the village of Portisham. Another still more remarkable example of such stones is afforded by the Agglestone near Studland in this county, the computed weight of which is 400 tons.

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whether of clay, gravel boulders or any other loose material, which could not have been formed or transported by causes now acting in the locality, such as violent floods, glacier-movements, icebergs, changes of level, &c., in contradistinction to *alluvial* action. Alluvial (from *alluo*, to wash and add together), includes those deposits which result from causes now in operation, as the partial destruction of land by rivers, land-slips, local floods, mountain torrents, growth of marsh-land, accumulation of sand-banks, mud and other deposits left by inundations. Dr. Buckland applies the term *alluvial* to the effects of the last great convulsion (the Noachian Deluge); *antediluvial* to the state of things immediately preceding it; and *post diluvial* or *alluvial* to that which succeeded it. Prof. E. Forbes restricts the term to deposits formed during the historic period.

* At the opening of the Deveril barrow, at Kimeridge, in the year 1826, several of these rude blocks were discovered in an erect position, placed in order, the largest measuring 13 by 7 feet.

Whence were these masses of stone derived? Referring to some in the neighbourhood of Puncknoll, Hutchins says, 'the common people have a tradition, that the devil threw them from Portland,'* but elsewhere adds, 'perhaps the stone might grow here.'

The geological theory adverted to in a previous chapter, removes any difficulty as to their origin, though it may be curious to know by what means stones of such magnitude were brought together, and in some instances raised several feet clear of the ground. These sand-stone boulders must not be associated with *erratic* boulders, which have their origin in places far distant from their present position. Thus the best collections of the fossils of Sweden are said to have been made in the north of Germany, from the boulders which had been transported thither by aqueous causes.

RAISED BEACHES, &c.

There are indications on this coast, that the present shore has not been for any very lengthened time the boundary of the sea, but that within a comparatively recent period, the ancient coast line has been elevated considerably above the existing high-water mark. This agency is probably still in operation, though only appreciable over a lapse of many centuries.† It is commonly said that the level of the sea has undergone a change, and not the solid parts of the earth. This, though it may appear to be the more simple solution of the question, involves in reality greater difficulties, as a rising or falling of the sea-level cannot be merely local, but must affect in the same degree the universal surface of the ocean.

The supposition, that the area under consideration, has within a period not very remote from the present time,

* Hutchins' 'History of Dorset,' vol. i. p. 218.

† On the European shore the rise of coast is most remarkable on the sea-board of Sweden and Scandinavia; the former having risen to a height of 200 feet and the latter 600 feet. This rising has been estimated to take place at the rate of 5 feet in a century.

been subjected to an upward movement, is founded on the following evidences.

At the 'Bill' or south end of the Isle of Portland, we have a consolidated beach or *breccia*, consisting of pebbles, broken stones, gravel, comminuted shells, and sand, united into one common mass by a stony calcareous cement. Though formed when these materials were on a level with the sea, it is now raised many feet above the reach of the highest tide.* Mr. Weston first drew attention to this ancient beach, 'Geol. Proc.' 1852, p. 110. Crevices and ledges of the cliff on the same point of coast retain numerous shells of species now living in the neighbouring sea, lodged in their present recesses when that portion of the cliff remained within reach of the tidal wave. Portions of raised beaches on other parts of this coast might have been expected to occur, but for the circumstance that, with the exception of Portland, it everywhere consists of yielding strata, which the sea would cut through faster than the land rose.

Again the presence of large irregular blocks lying beyond the line of the highest tides, contain the crypts of boring molluscs, not found in the stratum whence they were dislodged, but such as may be seen in rocks lying between high and low water. It may here be observed that the cliffs behind the Chesil Bank could never have been exposed to the waves of the West Bay. An elevation of land here seems more than probable.

Weymouth, or rather that portion of it north of the harbour and known as Melcombe Regis, rests on beds of shingle, alternating with sand, to all appearance but recently raised to their present position, the highest part not exceeding eight feet above the level of the sea at high tide.

* On the coast of Devon, Somerset, and Cornwall, similar accumulations exist.—See De la Beche's 'Report on Devon and Cornwall.'

These deposits on the coasts of the English Channel and the changes they indicate are fully and very ably treated by C. H. Austen, Esq., F.R.S., F.G.S., in 'Geo. Proc.' vol. vi. p. 69, vol. vii. p. 118, vol. xiii. p. 41.

Furthermore, the remains of an ancient sea-beach overspreads at intervals the bed of the Weymouth and Radipole Backwater, of which there is sufficient evidence in the quantity of stones collected for ballast and road-purposes. That they were drifted up the harbour channel does not appear probable, and, being unlike those lodged by river action, favours the supposition that this area was once open to the sea, and subsequently closed by the rising of the strip of shingle on which Melcombe Regis is built. The pebbles of this ancient beach are chiefly calcareous, containing fewer flints than are found on the present shore, and to all appearance derived more from local materials. The grey stones of the neighbouring Cornbrash have supplied a portion. These rounded pebbles must not be confounded with the deposits of angular flints, also largely spread a few feet below the bed of the backwater, these being of a different epoch and derived from inland. The bluish-coloured clay just under the surface, full of the dead shells of *Scrobicularia piperata*, *Cardium edule*, &c., appears to be of Pleistocene origin, as the living shells are found at greater depths.

On the slopes of the valley at Preston, which terminates on the coast, there is a drift deposit of yellow loam, containing numerous land-shells of existing species, and in addition, marine species of kinds that are still being lodged on the adjacent shore. A section of the above deposit, which rests on the Calcareous grit of the Coral rag, may be very clearly seen in the cliff, as it rises on the east side of the valley to a height of from ten to twelve feet above high-water mark. The occurrence of land-shells in the situation referred to may be accounted for by the river, which is now a mere stream, having once flowed to a greater height; but the presence of marine shells would seem to be due to the encroachments of the sea up the valley when the land stood at a lower level than at present. A rise of the coast line appears the only explanation that can be offered.

SEA-WASTE—LAND-SLIPS—ATMOSPHERIC AND OTHER DEBRIS.

The agencies enumerated at the head of this chapter embrace those superficial changes that proceed under our daily observation. These having been in operation during the historic period, are found associated with works of human fabrication, while in the more consolidated formations hitherto described no traces of man or his productions have been observed.

The action of the sea on our coast, and the no less wasting process of land-springs, are important agents in wearing down and redistributing the solid parts of the earth. The rate of destruction is determined by the nature of the strata and various other causes. Where the cliff is composed of the older rocks the waste is slow. In the Oolites, interstratified as they are with bands of softer clay and sand, it is more rapid, of which we have an illustration in the debris which fringes the Weymouth coast. The porous beds, percolated by springs, force a passage towards the cliffs, carrying in their course the softer and more yielding portions. At Portland this action is attributable to the position of the Kimeridge clay, which forms the substratum of the island. The springs passing through the numerous cracks which traverse the solid beds above and behind, and causing an undermining and consequent precipitation of the superincumbent mass. This was illustrated in the recent land-slip of Dec. 26, 1858, when the sliding down of an extent of undercliff covering an area of twenty-five acres, caused the sinking of an enormous mass of broken stone, the debris of adjoining quarries, and the accumulation of very many years. The scene of this occurrence was on the west side of the island, overlooking the West Bay. In ascending from the beach shortly after the occurrence, the observer would be first attracted by the low undercliff of Kimeridge clay, which, from lateral pressure, was pushed forward beyond the beach into the sea, and forced upwards with the shingle over it, so as to present an escarpment or outer face towards the sea. A little way up the cliff a singular change was effected in the position of some garden plots, which previously inclined towards the sea at an angle of 45°, but dip now as much in the opposite direction, the plane of this portion of land having consequently traversed 90°, or one-fourth of the circle. The entire ground from the beach upwards was rent with innumerable cracks, running in lines parallel to the coast, and rising in a series of steps or terraces. For many years the debris of the adjoining quarries had been thrown from trucks over the cliff, forming a kind of causeway extending some forty feet, all of which sank bodily down into basin-shaped cavities beneath, and carried with it portions of the main cliff. Either from the sudden withdrawal of this enormous mass, or the undermining which had gone on below, there was a partial severance of a large part of the solid cliff, which has left an open crack several inches in width.

The north-east side of the island has been the scene of some extensive land-slips, some of which are recorded in Hutchins' 'History of Dorset.'*

2 Feb. 1615.—The pier was demolished; blocks that lay 40 yards off in the sea were risen above the water, and the ways leading from the pier to the quarries were turned upside down, and sunk in several places 30 feet. The earth for 100 yards slid into the sea. It was conjectured that this was occasioned by a great quantity of rubbish thrown over the cliff upon a clayish foundation, which, softened by the rain, gave way.

1694-5. Another occurred.

December 1734.—An exceedingly wet season. 150 yards of the N.E. end of the island sunk into the sea, by which a pier and road were destroyed, and the damage computed at 40,000*l.*

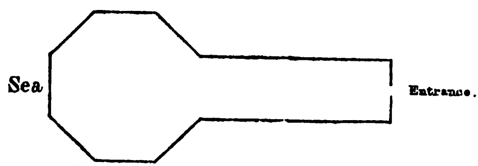
Feb. 13, 1792.—Another slide took place, more violent, more ruinous than either of the two former, of which a description is given by Francis Steward, Esq., receiver-general of the land-tax for the county. At 2 o'clock P.M. the ground had sunk several feet, and was one continued motion, with no noise but such as was occasioned by the

* Vol. ii. 2nd edition, p. 366.

separation of the roots and brambles, and now and then a falling rock. At night it seemed to stop a little, but soon moved again, and before morning the land from the top of the cliff to the water-side had sunk 50 feet perpendicular. The extent of ground thus moved was one mile and a quarter N. to S. and 600 yards E. to W. One effect of these landslips is shown by the present position of the old burying-ground, which has been launched from the level of the land above into the valley seawards. The insulated condition of large portions of cliff near Pennsylvania Castle are due to the same cause.

The present site of Sandsfoot Castle marks the rapid waste of cliff where stony strata alternate with clay and sand. The library of the British Museum (King's Library, No. 18, D. 111) contains a map of Dorset, published 1579, the oldest extant, in which this castle is placed, not far from the centre of the field, and surrounded by a moat. The following is a ground plan of the castle as it then stood.

SANDEFFOOTE CASTLE in the 16th Century.



Parallelogram, 100 feet long by 50 feet wide.

FAULTS.

In a district where strata of so many different ages have been brought to the surface in a comparatively small area, those interruptions, technically termed faults, may be expected to occur.

A particular stratum is traced to the face of a valley or break, and on looking for its reappearance at the same level on the other side, we find one of different age. The cause of this is easy to understand. A subterranean movement lifts the overlying strata, until (incapable of further flexure) it fractures, and then becomes raised in an unequal degree. This is further illustrated when the side or section of the raised portion is marked by grooves or deeply indented scratches, such as would be produced by the abrasion of the two surfaces under enormous pressure. Faults are of different geological dates, as in some cases they reach to the surface, while in others the plane of the superior strata is undisturbed. Here they communicate to the Chalk inclusive, and therefore were formed subsequently to the deposition of that formation.

Ridgway Fault extends in a direction east to west, and can be traced from Ower Moigne to the sea at Abbotsbury; but it is probably of much greater length, as on the west it runs under the sea, and on the east into the Chalk. This fault Dr. Buckland names the "Great Ridgway Fault." Sir H. De la Beche conjectures that it is connected with the east and west dislocation which passes through the Isle of Wight,* and as this enters the tertiary strata, the upheaval must have taken place at a Post-tertiary date.

Dr. Fitton has in his map of the south-east of England, and of the coast of France,† marked the course of this

* 'Geological Manual,' De la Beche, 2nd edit. p. 168.

† 'Geo. Trans.' 2nd series, vol. iv.

fault as an anticlinal line from the coast at Abbotsbury to Swanage, from thence under the sea, crossing the Isle of Wight to Sandown Bay.

A fault of such magnitude involves the production of minor fractures, some in the same direction, others transversely to them; but the surface of the country having undergone numerous changes from denudation, land-slips, &c., their existence is only made known by different beds of the same strata, or by strata of various ages being brought in contact. The main feature of the Ridgway fault is, that the Portland stone has been raised relatively to the Chalk and Greensand, inasmuch as the Portland beds, belonging to a formation below the Chalk, is brought on a level with it—both dipping to the north, the Chalk being situated on the north side of the fault and the Portland stone on the south. East of Moignes Down, the fault traverses a valley of denudation, the two sides of which are occupied by formations of different ages. At the top of the hill over the village of Bincombe, the Portland stone and Chalk are in contact. A little further to the north, the Kimeridge clay and Greensand abut upon each other. At Upway the Purbeck beds on the south are on a level with the Chalk on the north. At Portisham the Kimeridge clay is on the south, and the Chalk on the north, while at Abbotsbury the Coral rag is found on the south side, and the Greensand on the north.

The position and course of many of these faults can only be traced by consulting the map of the Geological Survey (No. 17). The minuteness and accuracy with which the fractured strata of the district are here laid down by Mr. H. W. Bristow, is a striking proof of the great care and labour bestowed by the officers of the geological survey upon their valuable publications.

Osmington Fault extends in an east and west direction, and is 6 miles in length. It emerges from the Chalk at Holworth and intersects the coast west of Osmington Mills, and again at Ham Cliff, whence it is represented on the map of the Geological Survey as running parallel to the great Ridgway fault. At Ringstead the effect of this disturbance has been to let down the Portland stone into juxtaposition with the Kimeridge clay.

At Ham Cliff the Coral rag on the south side of the fault has been lowered to a level with the Oxford clay on the north (see Fig. 27). Numerous other faults, coinciding in their course with those named, are shown in the map referred to; one extending from the village of Nottington, through Buckland Ripers, to the sea at the Fleet; and within a mile to the north another, parallel to this, passing through Holwell and Wyke Wood. It is only by the assistance of the map of the Geological Survey that these minor fractures can be traced.

Weymouth Saddle or Anticlinal. This singular condition of the strata is exhibited in the arrangement of the beds lying between Weymouth and Upway, where an anticlinal axis* forms a ridge in the Forest marble,† on either side of which are laid in regular succession, or sequence, the zones or strata of the *Oxford clay*, *Coral rag*, *Kimeridge clay*, and *Portland stone* (see section in frontispiece); the direction of the strata being north-east to south-west. Thus, on the south side of the saddle reposes the Oxford clay, crossing the peninsula of Weymouth, from Lodmoor to the shore at East Fleet, and succeeded by the Coral rag, which with its subordinate beds forms another zone, extending from the Nothe, or jetty-point, to Wyke Regis; the Kimeridge clay forming the substratum of the Island of Portland following, and lastly, the Portland stone. This order of succession is repeated on the north side of the saddle with the addition of the Purbeck beds, Wealden, Greensand, and Chalk.

* Where strata are raised to form an arch and to dip on either side in opposite directions, like the two sides of the roof of a house, the line forming the upper part from which they diverge is called the anticlinal axis. Where the strata incline inwards from either side, the corresponding line is termed the synclinal axis.

† The Forest marble, though in its natural position it is the lowest of the Weymouth strata, has been raised to the surface, and occupies the central stratum.

SUMMARY.

From the preceding pages it will be seen that the district under consideration has, within the period on which we have treated, undergone a succession of changes; that not only has the present land been covered by the sea, but that both land and water have many times changed places. Though we cannot take cognizance of any other formation lower than the Jurassic, yet the older strata, which are of considerably greater thickness, lie beneath, and may at some future epoch be brought to the surface. That the strip of land on which Melcombe is built was formerly covered by the sea—from which it is still gradually emerging—is evident from the composition of its mass, viz., shingle, gravel, and sand; but immediately under these comparatively recent accumulations is the Oxford clay, a stratum formed from the detritus of older rocks at the bottom of another and more ancient ocean, the boundaries of which had nothing in common with the present coast. Large ammonites and various mollusca, so numerous in this formation, belong chiefly to genera which have their allied representatives in warm seas of the present day. The remains of *Ichthyosauri* and *Plesiosauri*—shore-haunting creatures—would imply that at one period a shallow bottom or shore was not very remote.

Though few of the animals that lived during the deposition of the Oxford clay survived to the succeeding age, yet other forms appear; for the sea, during the formation of the Coral rag, swarmed with life. *Corals*, *echinidæ*, *mollusca*, *sharks*, having lived their appointed time, were replaced by others, who in their turn yielded to some general law by which all species eventually die out, never to reappear. The succeeding strata are a repetition of marine deposits, each change involving the successive creation and extinction of animal and vegetable life.

Thus, in the Kimeridge clay, a formation rich in organic remains, there occur huge Saurians of the genus *Pliosaurus*, which are only found in the Kimeridge clay; consequently the whole lifetime, not merely of the individual, but of the entire race of these animals was consumed during the accumulation of this one stratum.* During all this time the adjacent hills were submerged beneath the sea, until the close of the Portland oolite, which appears to have been the first land raised from the Jurassic ocean, and from certain changes in the configuration of the land the area so raised became a freshwater lake, covering a surface, the minimum extent of which is marked by the "cap." That this change was rapid in its character is proved by the sudden disappearance of marine fossils and the substitution of freshwater shells, for there is no transition or alternation between the Portland and Purbeck formations, the line of separation† being a bed of stone a few inches in thickness, the lower portion of which is Portland (marine), and the upper Purbeck (freshwater). Subsequently, by a further elevation, this estuary or freshwater lake is emptied of its contents, or is raised sufficiently to become dry land. This period, so distinctly marked, forms one of the most singular and remarkable features of this district. A forest of tropical luxuriance springs from the land recently raised from the sea. Coniferous trees and cycadeæ, although changed into flint, still lie in their primitive soil. Though geologists do not venture an opinion upon the length of time necessary to the accumulation of any one stratum composing the earth's crust, yet the condition of the fossil trees of the Portland dirt-bed, demonstrates that the whole

* Though there are no data by which we may learn the time that is required for a newly-created species to pass through its earlier stages, multiply, spread, reach maturity, and then gradually die out, yet, if we may judge from living animals and plants, 2000 or 3000 years appear to have made little or no change; some three or four species being all that are known to have disappeared in that time.

† In the Island of Portland there is a thin seam of clay above the Portland beds.

period which gave origin to the growth and destruction to this ancient forest was passed during the formation of a deposit but a few inches in thickness.*

The relative position of the land and water is once more changed, for the forest is submerged, and becomes the bed of a freshwater lake,† by a transition so gentle that the light soil of the dirt-bed is not removed. Of the succeeding beds, which consist, of dry land, shallow freshwater, and brackish-water deposits alternate, the Rev. Osmond Fisher has defined 162, each having a distinctive character most prolific in new forms of life, and terminating with the Wealden formation, which closes the Jurassic age. The area, which is our standing point, becomes once more the bed of another ocean, the waters of which teem with new life. This period, known as the Cretaceous, embraces strata, commencing with the Lower Greensand and terminating with the Chalk, and is of vast thickness. Still, the land that now meets the eye was originally formed beneath the sea.

The Tertiary formations are here but scantily represented, but their number and thickness elsewhere show that the

* The author of Omphalos (An Attempt to Untie the Geological Knot, by P. H. Gosse, F.R.S.) considers fossil remains to be delusive in the sense in which they are generally regarded. He compares the "life history" of an animal or plant to a circle, and creation a "sudden bursting into this circle," which may be at any point; according to which theory the petrified trees of the Island of Portland never had their term of life; the rings of annular growth, and other indications of preceding existence which they offer, are unreal developments. Mr. Gosse argues on the supposition, that though Adam was created "man," yet he presented all the evidences of having passed through the previous stages of life.

† An illustration of the changes which have taken place in the Portland and Purbeck beds has lately occurred in the kingdom of Savoy. "A geological phenomenon appeared lately in Savoy which will attract the notice of geologists. At Orcier, in the mountain chain above Thonon, a part of the land suddenly sank, and in its place a lake was formed. The chestnut-trees disappeared entirely with the ground on which they stood. A channel was also formed which drew off the surplus waters of the lake," &c.—'Athenæum,' Feb. 18, 1860.

period over which they extended was incalculably great. At the close of the tertiary period, the bed of the sea had been raised so as to form dry land; but the sea barrier, which now separates us from continental* Europe had then no existence.

Then it was that Great Britain was the resort and abode of the *mammoth*, *mastodon*, *hippopotamus*, *rhinoceros*, *cave lion*, *bear*, *hyæna*, and other animals whose semi-fossilized remains occur in gravel and other superficial beds, and in caverns, and in fissures, (as in the Island of Portland,) until the severance of this land from the Continent rendered their imigration here no longer practicable. Later still was that convulsion which is supposed to have given rise to the denudation by which large portions of the superior strata were removed, the valleys excavated, and the surface of the land had much of its present form and outline given to it; yet the interval between that, the last great geological change, and the present, appears to be very great, unassociated as deposits of that period are with all

* That Great Britain was, until a comparatively recent period, united to the Continent, is placed beyond all reasonable doubt. The Oolite of Weymouth has its counterpart on the coast of Normandy. The Chalk of Dorsetshire and the Isle of Wight on the coast of the Seine Inferieure, and there is a similar correspondence of parts in the tertiary formations. Besides this similarity in the structure of the land on both sides of the Channel, there are other evidences derived from the living species of animals and plants of Great Britain and the Continent. Prof. E. Forbes has, in an interesting communication on this subject, shown that the animals and plants of living British species are chiefly of Germanic types, and could only have found their way hither by strict communication with the Continent over land.

The greatest sea-depth between Weymouth and Cape la Hogue is 45 fathoms, between Dover and Calais 30 fathoms. Supposing the bed of the English Channel raised 100 feet, a bar which crosses from the coast near Newhaven to Dieppe would be dry land.

The agency by which Great Britain was separated from the Continent is still a subject of dispute. By some it is supposed to have been caused by a subsidence of the Channel area, by others that it originated in a fissure which, by long-continued action of the sea, has attained its present width.

vestiges of the remains of man. That many centuries pass without producing any very perceptible change in the surface of the earth, we know from the condition of works of great antiquity.* The tumuli, with their sepulchral contents, Druidical temples, and other monuments around us, have undergone little change since their erection or foundation 2,000 years ago. From such evidences, what conclusions may be deduced, but that the object of this volume is to present facts rather than to theorize?

This retrospective survey of the revolutions and changes of which this area has been the scene, may be appropriately closed in the following words of a highly gifted Christian philosopher—"The earth on which we live must ever be considered a proper subject of investigation. For man it was made, and so carefully preserved; its surface is the arena of our contentions, our pleasures, and our sorrows. It is to obtain a portion of its alluvial crust that man wastes the flower of his days, prostrates the energies of his mind, and risks the happiness of his soul; and it is beneath its verdant turf that his ashes are to be scattered or his bones to be laid. To him, therefore, it specially belongs to investigate the wonders it displays, and to learn the lesson which it reads."†

* Some of the most ancient structures in the world, the Pyramids themselves, are built of one of the most recently-formed stones, viz., the Nummulitic limestone, a member of the Tertiary formation, so called from the great number of Nummulites (a singular fossil) which enter into its composition. At the base of the great pyramid these fossils, derived from the disintegration of the stone above, have accumulated to a thickness of 12 feet. Mr. H. Ward of Paris, to whom I am indebted for the latter fact, informs me that the quantity of the fossils referred to is truly astonishing.

Strabo in his day noticed their occurrence in the vicinity of these monuments, and imagined them to have been the petrified residue of the lentils brought there by the workmen, from their having been the ordinary food of the labouring classes and of all the lower orders of Egyptians. See also Wilkinson's 'Ancient Egyptians,' vol. i., p. 167. Murray. London, 1854.

† Sir D. Brewster, Address, Brit. Association, 1850.

APPENDIX.

CHESIL BEACH.

This remarkable feature of the Dorsetshire coast, exceeding in magnitude any other formation of the kind in Europe,* connects the Isle of Portland with the mainland at Abbotsbury (a distance of 10¾ miles), from which point it runs along the shore, rapidly diminishing in extent, to Burton Cliff, 16 miles west of Portland. Its breadth at ordinary low tides was computed by Mr. Coode at 170 yards near Abbotsbury, and at Portland at 200 yards, with an average height of about 40 feet. The size of the pebbles increases in a direction from west to east, being at Abbotsbury but little larger than coarse gravel, and towards Portland from 1 to 3 inches in diameter, with occasionally some of larger dimensions. It will also be observed that the larger pebbles are flattened, as though they had been worn away by being pushed forward while the smaller ones were rounded by being rolled along the bottom. Camden, Leland,† and Holingsworth, say that

* A raised mass of shingle, the largest probably in the world, is described by Darwin as extending from near the Rio Colorado to a distance of 700 nautical miles, with an average breadth of 200 miles, and a depth of 50 feet.—Darwin's 'Journal of Researches,' p. 171.

† Leland gives us this particular account of the island and its environs in his time:—

"This arm (viz. that runneth up by the right hand of Waymouth Haven, to Portland Passage; see Waymouth) goith up from the Strait of Trajictus, and is of a good bredth, and so se goith up to Abbates-Byri, about a vij. miles of, where is a litle fresh water resorting to the se. A litle above Abbates-Byri is the head or point of the Chisil, lying North Weste, that from thens streach up 7 miles, as a maine narow banke by a right line on to South Est and ther buttith on Portland, scant a quarter of a mile above the new castell in Portland. The nature of this bank of Chisil is such, that as often as the wind blowith

Portland was once an island. This could scarcely have been its condition within the historical period, though at one

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strene (f. strong) at South Est so often the se betith it, and losith the bank, and breakith through it. So that if this might continually blow there, this bank should sone be beaten away and the se fully enter and devide Portland, making it an isle, as surely in tymes past it hath beene, as far as I can by any conjecture gather. But as much as the South Est wind dooth bete and breke off this Chisille bank, so much doth the North West wynd again socor, strength and augmentith. On the farther point of the Trajictus into Portland, comming from Waymouth, is a point of land like a causey al of pible and sand, cast up by the rages of the se. Wheron I went scant a mile, to the lowest part of the rotes of the high ground of Portland, wher a late a right strong and magnificent castel is buildid at this causey end. And from this castelle to the very South Est point of the Chisil, is but a little way: and the arme of the se that goith up to Abbates-Byri, gulfith in bytwixt the South Est point of the Chisil and the castelle.

"Portland has been of auncient tyme, by all likelihod environid with the se, and yet berith the name of an isle. It is eminent and hilly ground on the shore of it and a great plain in the midle of it. The cumpace of it is countid to be about a 7 miles. But if a man should cumpace it by the very rootes, and depe shore would mount to a 10 miles. The soil is somewhat stony; and the shore very rokky.

"The isle is fruiteful of corn and gresse and hath plenty of sheepe. Ther be at this present tyme about a 80 housis in the isle.

"Ther hath been almost as many mo, as it apperith by the ruines. Ther is but one streat of houses, in the isle the residew be sparkelid. Ther is a castelet or pile not far from (the) streate, and is set on a high rokke, hard by the se cliffes, a little above the Est end of the cherch. The paroche cherch, that is but one at this tyme in the isle, is longe, and sumwhat low buildid in the hangging roots of an hill by the shore. This cherch and paroche is about a mile *dim*—to go the next way to it from the Kinges new castelle, in the isle; and to go to it by cumpace of the shore it is 3 miles, or more. Sum say that in tymes past, ther was another paroche chirch in the isle; but I there lernid no certente of it. There be very few or utterly no trees in the isle, saving the elmes about the chirch. There wold grow more, if they were ther plantid; yet is the isle very bleke. The people bring wood thither, out of Wight and other places. They brenne also cowe dung dryed with the hete of the sunne. The people of the isle lyve most now by tillage, and sumwhat faulle from fishing. ["The time it was probably separated from the mainland. The blue clay on which the shingle has accumulated, having been a reef or shallow bank, served to arrest the pebbles, which but for this obstruction, would have been driven farther to leeward.

The Chesil bank is an example of the sea producing a barrier to its own progress, and the destruction of one part of the coast becoming the means of protection to another portion. It effectually checks the heavy waves of the Atlantic, which would otherwise encroach on the land behind, and probably sweep away the bed of shingle on which Melcombe is built.

The Fleet, a narrow arm of the sea that separates the Chesil Beach from the mainland, is the necessary result of a bar thus thrown up, which by preventing the escape of land-springs from the shore behind, forms an inner channel, the level of which with the outer sea is preserved by the surplus water percolating into it through the shingle. Weeds, on a flat shore, are not unfrequently thrown up in the form of a ridge, leaving a lagoon or inner belt of water on the land side.

Whence is this mass of shingle derived? From the bottom of the sea-offing? Trawlers and others who dredge the West Bay report it to be singularly free from pebbles. From Portland? That would imply that they travelled not only against the prevailing winds, but also in a direction contrary to that of the waves; moreover, with the exception of some comparatively small portions of flint, the Portland beds are calcareous, while the pebbles of the Chesil bank are siliceous.* The materials forming shingle

"The people be good there in slyngging of stonys, and use it for defence of the isle. The people ther be politique inough in selling their commodities, and sumwhat avaritiose. The personage sette in the high streat is the best building in the isle. The bishop of Winchester is patrone of the chirch. The isle is the Kinges; and much of the land there is holden by . . . . of hym."—Leland's 'Itinerary,' vol. iii. pp. 66, 67.

* Siliceous pebbles are so hard and crystalline that the point of a

beaches, which in most instances are derived from cliffs at no very remote distance, travel in a given direction. On both sides of the channel this is from west to east,* and is the result of the preponderance of westerly winds, both as regards their duration and force. If a groin or other projection is erected on the south or south-east coast, the accumulation of shingle is on the west side of such a barrier.† To effect this result it is not necessary that the prevailing winds should blow in a direction parallel to the coast; any wind which strikes it, however obliquely, will exert a force tending to impel the shingle in the same direction.

Of the pebbles composing the Chesil Beach chalk flints are the most numerous. A white semi-transparent quartz is identical with certain unrolled flints, which are found abundantly in the valleys of Abbotsbury, Chideock, and Charmouth. Others have been traced by Mr. Coode to the chalk cliffs between Lyme and Sidmouth; some, of a different character, to Budleigh-Salterton, and others to Aylesbere Hill, whence they were brought down to the coast by the river Otter.‡ The sandstone and older rocks of Devon have supplied por-

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knife or sharp instrument makes no impression on them, while marbles and other forms of limestone yield to that test. Sulphate of lime (selenite, gypsum, &c.) is sufficiently soft to be scratched with the nail.

* It deserves notice that the *raised beaches* at the entrance into Torbay—at Slapton, and on the coast of Cornwall, as well as those on the other side of the Channel, around Cherbourg and the Channel Islands, indicate that their materials while in process of accumulation travelled in a direction from E. to W., the reverse of the present movement. See 'Geo. Proc.' vol. vi. p. 69, and vol. vii. p. 118. R. A. Godwin-Austen, Esq.

† 'On Sea Beaches.' 'Philosophical Transactions,' 1834, p. 568.

‡ 'A Description of the Chesil Beach,' by Mr. J. Coode, M. Inst. C.E., read at the Institution of Civil Engineers, May 3, 1853. This paper contains a great amount of original and interesting information, founded on lengthened observation.

phyry and various coloured jaspers.* Though these data indicate the sources whence certain portions of the beach have been derived, the rate of supply from them

* The pebbles of the Chesil Beach will rarely repay the cost of cutting and polishing. It may not be out of place here to remark that many agates, onyxes, and other stones so largely sold in this country of late years, were of German origin, and in many instances artificially produced. The fraud was not for a long time detected; but their abundance and the pattern being only on the exterior, awakened suspicion.

At Oberstein, a village near Bingen on the Rhine, igneous rocks are traversed by veins of a kind of agate or chalcedony, which (when submitted to an artificial process) assumes the deep red colour of carnelain; others become dark brown or chocolate-coloured; and in some instances, where the bands or layers are strongly contrasted, the effect is to produce alternate black and white, or brown and white layers, resembling those of the onyx.

The more beautiful agates are from the neighbouring mountains of Idal, where, as at Oberstein, there are polishing mills. ('Geo. Pro.' vol. iv. p. 209; 'On the Agate Quarries of Oberstein,' by W. J. Hamilton, Esq.). Prof. Noeggerath, of Bonn, considers that "all the onyxes of the present day are the result of the above treatment, and, there is good reason to believe, many of the ancient ones." In confirmation of this view, see chapter on Gems in Chambers' 'Edin. Journal,' Nov. 1855, for authenticated instances of stones of fictitious character sold for costly gems.

The Egyptians, more than 3000 years ago, succeeded in counterfeiting precious stones. Pliny says that they succeeded so completely in the imitation as to render it difficult to distinguish false from real stones, and considers the art to have been a far more lucrative piece of deceit than any other devised by the ingenuity of man. (Pliny, xxxvii. 12.)

The agate trade at Oberstein and Idal has lately undergone a singular change in consequence of a falling off in the supply of the agate nodules. The agates now worked in that district, and sold as native productions, are chiefly obtained from the Brazils, where, on the Paraguay, brought down from the interior by the Rio de la Plata, they are in such abundance as to be shipped for ballast. Notwithstanding the source of supply is so remote, agate articles are sold in Germany at prices astonishingly low. One other fact in connection with the agate frauds may be worth recording. Upper Egypt is known to yield agates, though different from those of South America, and much is not sufficient to account for the formation of a deposit of such vast magnitude. The sea produces little effect on the older rocks: the chalk which furnishes the flint is of a more yielding nature; but even there the waste of cliff is comparatively inconsiderable—scarcely more than sufficient to supply flints enough to make good the loss occasioned by attrition and removal.

If causes now in operation are admitted to be inadequate, and we are to look for other agencies, the view taken by Dr. Buckland appears not improbable. He supposes that the diluvial waters which excavated the extensive valleys intersecting the coast at Abbotsbury, Chideock, Charmouth, &c., swept their materials into the bed of the British Channel, whence they have been drifted into their present positions by the influence of the prevailing winds blowing from the south-west.*

It has been noticed that the largest pebbles are towards Portland, the leeward extremity of the bank. Had the reverse been the case, possibly the fact would not have been discussed, as it might be supposed that the smallest pebbles would travel farthest, or that those which had travelled farthest would be worn down to the smallest size. Some consider this circumstance to be due to the tidal action of the sea, others to the velocity of the waves, increasing gradually from the north-west to the south-east (the direction of the beach), and therefore that the size of the pebbles thrown up would be largest where the force of the sea was greatest. Mr. Coode is of opinion that large pebbles, from offering a larger surface to the power of the water, are more easily moved than smaller ones. Their occurrence at the summit of the bank results from the force of the advancing being greater than the

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less abundant. Travellers from Europe in passing through that country inquire for these; and, to meet the demand, Brazilian agates are now sent to Egypt, and there sold for Egyptian agates. At Cairo, especially, numbers are thus disposed of to English and other travellers, who purchase them as souvenirs of the country.

* 'Reliquiæ Diluvianæ,' p. 246.

retiring wave, in the same manner as on a sandy shore the heaviest substances may be observed to be thrown up the farthest, because the wave by which they were lodged, in consequence of being dispersed or divided into spray, returns to the sea with diminished force.* The position of the shingle lying within reach of the waves, undergoes considerable modification according to the direction and force of the sea, the motion thus imparted to the shingle being either a destructive, an accumulative, or a progressive action. As an illustration, Mr. Palmer watched at Dover, during a gale of wind, the rate of succession which exhibited the destructive and accumulative action in their smallest degree, and observed, that when ten breakers arrived in one minute, the destructive action was but just evinced, and that when only eight breakers arrived in the same period, the pebbles began to accumulate; which harmonized with other observations he made elsewhere.† Mr. Coode considers "seven or any less number of waves per minute as inducing the destructive action, and nine or any greater number in the same time the accumulative action."

The many curious relics that have, at various times, been here thrown up from the sea, invest the Chesil Beach with an antiquarian interest. Coins of gold, silver, and copper, both of ancient and modern date, are of frequent occurrence. Of the former, those of the Roman Empire are the most numerous, especially the "third brasses" of Constantine. The occasion of their being found is only after a continuance of ground-seas, when the waves receding in rapid succession, produce a downward current, scouring away the shingle and exposing the blue clay (Kimeridge) beneath. During the prevalence of a ground-swell there is but little wind, and the waves approach the shore at, or nearly at, right angles. The

* If two corks, one of which is weighted to sink to the bottom, be thrown into the sea, the floating piece keeps its distance from the shore while the weighted one will be thrown upon the beach.—Godwin-Austen, 'Geo. Pro.' vol. vi. p. 75.

† 'Phil. Transactions, 1834, p. 271.

most remarkable ground-sea that has occurred of late years, happened in 1841, and continued for several days, during which the shore was, for miles, thronged with persons searching the clay left bare by the recoiling waves, and quantities of coins were then collected. Besides coins there have on such occasions been found antique rings and seals, silver, and even gold ingots,* with other relics which have survived the destruction of vessels wrecked on the beach of this much-dreaded bay, and offering melancholy and singular evidence that the mariners of ancient as well as modern nations have here alike found a watery grave. A winter rarely passes without the Chesil Beach being the scene of some disaster.†

* Almost realizing the dream of the Duke of Clarence: —

"Methought I saw a thousand fearful wrecks;
A thousand men that fishes gnawed upon;
Wedges of gold, great anchors, heaps of pearl,
Inestimable stones, unvalued jewels;
Some lay in dead men's skulls; and in those holes
Where eyes did once inhabit, there were crept,
As 'twere, in scorn of eyes, reflecting gems,
That woo'd the slimy bottom of the deep,
And mocked the dead bones that lay scattered by."

SHAKSPERE.

† Nov. 1795.—A fleet under Admiral Christian, endeavouring to reach Torbay, encountered a gale in the West bay, which drove a large number of transports on shore, when 1000 persons were supposed to have perished.

March 27, 1815.—The 'Alexander,' from Bombay to London, with passengers and troops, was during the night driven on the beach opposite the village of Wyke, and all on board perished, excepting four lascars and one woman.

Nov. 23, 1824.—During this memorable gale, a large number of vessels were embayed and lost.

Oct. 1839.—In a gale of great violence, nine vessels foundered or were driven on the beach between Portland and Abbotsbury, with the loss of all on board, excepting one ship of 500 tons which was thrown in on the top of a wave high on the bank.

A change of wind or turn of tide restores the shingle to its place, and covers up again this storehouse.

On the Chesil Beach,* after a storm, may be collected many of the deep-water and rarer kinds of zoophytes, corallines, and algæ. It is the only known habitat on the coast of Great Britain for an elegant species of Cirripides, *Acasta Montagui*. Some rare plants grow on the north side of the bank, for the names of which see Appendix.

* Hutchins makes a curious contribution to the Natural History of the Chesil Beach :—

"June 1757, a *mermaid* was thrown up on the shore between Portland and Burton, thirteen feet long. The upper part of it had some resemblance to the human form, the lower was like that of a fish: the head was partly like that of a man, and partly like that of a hog. Its fins resembled hands; it had forty-eight large teeth in each jaw, not unlike those in the jaw-bone of a man."—History of Dorset, vol. i. page 338, 1st edition, 1774.

FORMS OF PETRIFACTION.

Fossils formerly included, not only the fossilized remains of organized bodies, but also minerals, ancient pottery, and all other relics dug out of the earth, but the term is now only applied to remains of animals and plants. These, though generally penetrated by earthy or mineral matter, are not necessarily so. In some instances the original shell or bone has undergone but little change of structure, while in others there has been an entire substitution of parts. The following will be found to include the various conditions in which fossils are preserved.

1. Where the constituent parts remain the same, without having undergone any other change than that resulting from decay; as for example, shells of comparatively recent date, cavern bones, elephant, and other diluvial remains.

2. Where the substance has become *carbonized*, as is the case with common coal, jet, and lignite.

3. When the original shell or bone has been replaced by some earthy or mineral substance, determined by the chemical nature of the stratum in which the body is imbedded. In the harder rocks, carbonate of lime,* sometimes silica or flint, is substituted for the original shell. In clayey beds, where iron pyrites is diffused, the original substance is frequently replaced by sulphide of iron. Fossils in this condition have a brassy appearance and a metallic lustre. Notwithstanding these changes of atoms, the original structure of the shell or plant, however delicate it may have been, is frequently preserved.

4. *Casts.*—Where the shell itself has disappeared and left only a hollow, as in the screw-stones and other fossils

* The basis of shells is *carbonate* of lime; of bones, *phosphate* of lime.

of the Portland roach-bed. In these the shell has entirely disappeared, each particle as it was gradually dissolved and carried away, having been replaced by one of calcareous spar, derived from the limestone in which it was imbedded, until ultimately a perfect facsimile was produced of the original shell. This in its turn was subsequently carried away in solution by the percolation of infiltrating water, leaving only a cast or mould of the shell, composed of the same stony matter as that of the rock in which it is enclosed. Though the shell has left a vacancy, the outer surface bears the impress of the external form of the shell, by means of which the species may be ascertained.

Another form of fossilization occurs in the shaly beds of the Oxford and Kimeridge series, where the harder parts of the shell have disappeared, and the internal and nacreous portion only is preserved. Foot-tracks of extinct animals, and impressions of rain-drops of an ancient world, are also included in the term fossil remains. To these may also be added *Fulgurites*, a term applied to certain appearances in ancient strata, caused, it is supposed, by lightning, and hence called *fossil lightning*, as in the same manner particular cracks considered due to the sun's rays, have been termed, though somewhat ridiculously, *fossil sunshine*.

Popular Description of the Fossils found in the Weymouth Strata.

Ammonites (*Cornu ammonis* of old authors).

A wide-spread and familiar fossil, named after Jupiter Ammon, from its supposed resemblance to the horns with which the head of that Deity was represented to be crowned. Early writers refer to them as fossilized rams' horns, others as coiled snakes* in a state of petrifaction.

* This idea is embodied in the following lines from Marmion :—

> "Of thousand snakes, each one
> Was changed into a coil of stone,
> When holy Hilda prayed."

[The

The latter belief may have given rise to the popular notion that an ammonite in a perfect state must have a head; and the inquiry for such has led the Portland quarrymen to carve the termination of the last whorl into the resemblance of a snake's head. Such *perfect* specimens may be had for a few shillings. To correct this error it is only necessary to state that the ammonite is not the animal but the shell which it inhabited, the former (a soft mollusc) being incapable of preservation. These interesting fossils are found in rocks of the secondary period in all parts of the globe, first appearing in the Trias and terminating with the Chalk. Its ally, the nautilus, still survives. Though of marine origin, ammonites have been met with on the Himalayan range of mountains, at a height of 17,000 feet above the level of the sea.* Above 300 species are recorded from the British strata alone, varying in size from less than an inch to four feet in diameter. The *Ammonites giganteus* found in the Isle of Portland frequently attains this latter size.

A fossil, *Aptychus latus*, until very recently supposed to be a bivalve shell, and named on that supposition, *Trigonelites*, is now regarded either as the gizzard of the animal, or the operculum or valve, which closing the outer chamber, served to protect the parts contained within the shell.

Some naturalists, considered the ammonite to have been an internal shell, *i. e.* enveloped by the animal.†

The legend runs, that the good people of Whitby having besought St. Hilda, that the snakes might either be destroyed or rendered harmless, she prayed first their heads off, and then their conversion into stone.

* Ammonites are used as charms by the Hindoo fakirs.—Murchison, 'Geol. of Russia,' vol. i. p. 256.

† "Shell external; animal unknown; supposed to resemble nautilus." (Owen).

The small interesting chambered shell *Spirula*, is considered by Dr. Gray, as (of existing genera) the nearest allied to the Ammonite. *Bifrontia*, a small chambered marine shell, also bears a strong similarity to the Ammonite in many of its characters.

This opinion was partly founded on the size of the outer or last chamber, which bore too small a proportion to the entire shell to have contained the animal; but in the best-preserved specimens the last chamber forms two thirds of the outer whorl, and therefore is proportionably as large as the outer chamber of the nautilus. Most specimens are broken off at the outer chamber, hence the latter appears contracted. That, like the nautilus, it was an external shell, appears probable, from the size to which some species attain, and the numerous spines characterizing others. Added to this there is the singular yet symmetrical termination of the outer chamber, which in some species terminates with a simple reflection, while others are slightly sinuous, as in *Ammonites Kœnigi*, plate 1, fig 1; while in *Ammonites Jason* this termination is lengthened out so as to present the appearance of two horns. The air-chambers enlarge with the growth of the shell, but have no communication with each other, the cell being hermetically closed as each partition was successively deposited. The septa or divisions, besides adding strength to the shell, appear to have been necessary, as in the case of the nautilus, to counterbalance the increasing weight of the animal as it grew, each chamber being lighter than the quantity of water it displaced. As is the case with the nautilus, the weight of the animal and shell combined was so perfect a counterpoise to the medium in which it floated, that the slightest effort of the animal would cause it to rise or sink. In the nautilus, this is effected by the ejection of a fluid into the siphuncle or pipe which passes through the chambers, and the adjustment is so perfect that a few drops suffice to sink animal and shell, and *vice versâ*.

The shell of the ammonite is distinguished from that of the nautilus by the siphuncle being situated on the outside of the shell. In the latter it passes through air-cells in its centre. The shell of the ammonite also offers mechanical contrivances of the most perfect description. Its numerous partitions, fluted exterior, sutures, ribs, keel, spines and bosses, all contributed to afford the greatest strength combined with the least possible weight. Some specimens, especially those from Lyme Regis, having their cells filled with a crystallization of carbonate of lime, are susceptible of a high degree of polish. The last chamber generally contains a different substance, supposed to arise either from the decomposition of the animal, or from its being thus occupied, prevented the surrounding matter from entering. About forty species occur in the Weymouth strata, varying in size from the minute species which is found in the Oxford clay, to the *A. giganteus* of the Portland series.

Belemnite (from βελεμνον, *a dart*).

A singular fossil not found in a recent state; straight, cylindrical, and pointed like a pencil at one end, with a conical cavity at the other; hard, of a crystalline texture, dark-brown colour, and emitting, when rasped, a peculiar horny odour. Unlike the ammonite, its shell was enveloped by the animal; resembling in this and some other characters, the *sepia* or *cuttle-fish.* It was also a compound shell composed of the following parts:—

1. The *guard* or *sheath, a;* see figs. 11, 12, 13, the portion generally preserved.

2. *Phragmacone* or *alveolus, b;* a conical shell lodged in the cavity at the base of the sheath, and consisting of a series of concave air-cells pierced laterally with a siphuncle, answering to the air-chambers of the ammonite and nautilus.

3. Above the phragmacone commenced a calcareous or horny plate, *c*, enclosing an ink-bag and other appendages. From recently discovered specimens, with these various parts preserved, Professor Owen has described the probable character of the animal to be that of a dibranchiate, eight-armed cuttle-fish.* It is supposed that the belemnite generally maintained a vertical position, and that its dart-like bone or shell gave it considerable swiftness of motion. The number of named species is

* Hunterian Lectures.

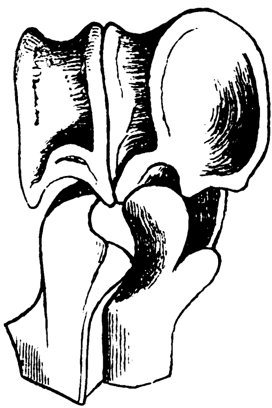
nearly one hundred. Commencing with the Muschlekalk of Germany and Lias of Great Britain, they enter into nearly all the ascending strata, disappearing with the Upper Chalk, and like the ammonite, never appearing again. Few fossils have given rise to so many speculations. M. Blainville enumerates ninety-one authors who have written on them, commencing with Theophrastus, B.C.

The following are among the names by which the Belemnites were designated—*thunder-bolts*, *arrow-heads*, *petrified fingers*, *St. Peter's fingers*, *stalactites*, *teeth*, *spines of echinidæ*, *petrified amber*, &c.; and in old works on Materia Medica, they are recommended to be used in a pulverized state as a remedy for nightmare, dressing wounds, &c. They are abundant in the lower beds of the Kimeridge clay at Sandsfoot Castle Cliff.

Saurians.

Of the gigantic reptiles that existed during the secondary period, the following (belonging to the order *Enaliosauria*, or marine saurians) are represented in the Weymouth strata.

Fig. 57.



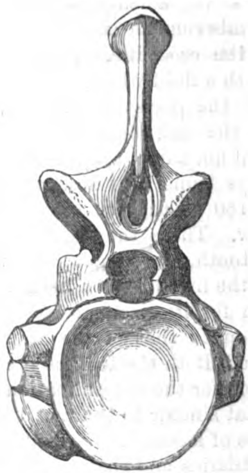
Vertebræ of Ichthyosaurus. Oxford Clay. Weymouth.

Ichthyosaurus (from the Greek ἰχθυς, a fish, and σαυρος, a lizard), was an animal combining the characters of lizard and fish, and in size the nearest approach to the whale, some species attaining a length of from 40 to 50 feet. The vertebræ, numbering 140, are concave as in fishes, and not solid as in the crocodile. The space between each pair was filled with a fluid which insured the utmost play and elasticity of the parts in question. These become smaller towards the tail, somewhat flattened, and terminating in a caudal fin, flat in a vertical direction, and in a fossil state always found bent downwards. The jaw was furnished with 180 teeth, not set separately, but in a groove or furrow. These they had in succession. The second or new tooth, and sometimes the third may be detected, where the first has not been shed. The eye is remarkable both for its peculiar construction and large size in proportion to that of the animal, and from its posterior position. Both the teeth and vertebræ offer distinctive characters for the determination of species. Four paddles, somewhat similar to those of the whale, supplied them with means of locomotion. Aquatic in their habits, they lived in estuaries and shallow bays, feeding on fish, the indigested remains of which are found within their skeletons in a fossil state. Thirty species are known to Professor Owen. The Lias of Charmouth and Lyme Regis is a well-known depository, whence specimens have been obtained that have found a place in nearly every geological collection in Europe.

The jaws and skull of an *Ichthyosaurus platyodon*, deposited in the Weymouth Museum, exceed five feet in length. Vertebræ and other bones of Ichthyosauri occur in the Oxford clay of the vicinity of Weymouth.

PLESIOSAURUS (from πλεσιος, near to, and σαυρος, a lizard).

Fig. 58.



Vertebræ of *Plesiosaurus arcuatus*, from the Oxford Clay of Weymouth.

The Plesiosaurus was an animal of nearly equal dimensions to the Ichthyosaurus, but differed from it in organization, especially in the greater length of its neck, which was longer in proportion to its size than is the case either with the swan or the giraffe. Hugh Miller aptly compares the Plesiosaurus to a snake pushed through the body of a turtle. The vertebræ are ninety in number, thirty-three of which belong to the neck. Compared with the Ichthyosaurus the head is shorter, the vertebræ are smaller in diameter, but considerably thicker. The paddles are also larger. Its general structure indicates great agility and speed. It was a shore-frequenting animal, like the turtle: more so than the Ichthyosaurus. Cuvier conjectured, from certain anatomical appearances, that it had the power of changing the colour of its skin, and further adds, with regard to its general form, that it possessed characters altogether the most monstrous that have yet been found amid the ruins of a former world. There are twenty known species. *Plesiosaurus planispondylus* occurs in the Oxford clay of Greenhill and Radipole Backwater. *Plesiosaurus megapleuron* (Owen) is found in the lower beds of the Portland stone in the Isle of Portland.

Pliosaurus.—A genus but recently described, having somewhat of the character of both Ichthyosaurus and Plesiosaurus, but bearing a greater resemblance to the crocodile than either of the above. The teeth are of greater thickness compared with their length; the outer sides are much flattened, besides being longitudinally grooved, and having an unusually lengthened fang; they are fewer in number and set separately in a socket as in the crocodile. The vertebræ bear more resemblance to those of the Ichthyosaurus, but are less concave. Only two species are recorded—both from the Kimeridge clay. No entire animal has yet been found. The teeth, a portion of the head, vertebræ, and other bones of the *Pliosaurus brachydeirus* (Owen), deposited in the Weymouth Museum, are from the Kimeridge clay of Ringstead. Single vertebræ are not uncommon in the Kimeridge beds at Osmington Mills, Ringstead, Kimeridge, and Portland.

Teleosaurus.—An animal more adapted for motion on dry land than most other saurians, and therefore like the modern crocodile, most probably amphibious in its habits. The first recorded specimen, from the lias shale of Whitby, measured 18 feet in length.

The skin of the *Teleosaurus* was overlaid with massive plates or scales, forming a kind of coat of mail like that of the crocodile. The teeth were about 140 in number, and slender, of which the first, on either side of the jaw, was long, and the others alternately longer and shorter. The jaws of the Teleosauri were long and attenuated.

Locality—Lower calcareous grit of the Coral rag of Nothe Point, Weymouth.

LIST OF NEWLY DESCRIBED SPECIES INCLUDED IN THIS VOLUME.

1. *Lima Coodei*, n. sp. fig. 36.—Shell very oblique, compressed, umbones contiguous, depressed, and but little produced; anterior border straight, not excavated, slightly gaping: posterior border and auricle elliptically rounded; ribs (about 28) large towards the middle of the valves, diminishing regularly in size towards both extremities of the shell, depressed, smooth, and much wider than the interstitial spaces; lines of growth faintly marked and irregularly disposed. Height, 2½ inches; anterior posterior, 2 inches; diameter through both valves, 1 inch.

From the Portland oolite, Island of Portland.

2. *Corbicella Portlandica*, (Psammobia ?) n. sp. fig. 37.—Shell transversely ovate or subquadrate, compressed inequilateral, umbones small, placed about one third from the anterior margin, which is rounded; posterior side with a rather obtuse ridge extending from the umbones to the margin, which is somewhat attenuate; surface marked by lines of growth. Allied to *Corbicella bathonica*, (Lycett). This shell is provisionally placed with Corbicella, but the specimen figured shows indication of a deep pallial sinus, as in Psammobia. It is a rare fossil.

Locality—Portland stone, Isle of Portland.

3. *Sowerbia Dukei*, n. sp. plate 7, fig. 6.—Shell ovate, oblong, equilateral, thick anteriorly, and posteriorly rounded. The cast figured shows the cardinal area, the prominent anterior and posterior muscular impressions; the pallial line and slightly inflected sinus.

This shell belongs to a small group of oolite forms, for which D'Orbigny proposed the name *Sowerbia*, to which also belongs the genus *Isodonta* of Buvignier.

Locality—Portland stone (roach bed), Isle of Portland, associated with *Cerithium Portlandicum*, *Trigonia incurva*, &c.

4. *Lithodomus Portlandicus*, n. sp. plate 7, fig. 11.—Smooth, lines of growth faintly impressed; more elongated and compressed than *L. inclusus*.

Locality—Portland oolite, Island of Portland.

5. *Trigonia marginata*, n. sp. plate 6, fig. 8.—A large costated and oblique trigonia, with prominent, nearly straight, marginal carina; large flattened area and very oblique ribs. The umbones are elevated and but little recurved, the large marginal carina is but slightly impressed by the transverse plications. The inner carinæ are very small, and scarcely distinguished from the delicate oblique plications upon the area; the elliptical post-ligamental space is large with oblique knotted plications; the costæ (about twenty-two) not much elevated, oblique, slightly curved at the extremities. The cast is smooth, exhibiting very large hinge teeth. The area is finely reticulated, as in *T. meriani*.

Locality—Lower bed of the Kimeridge clay, Ringstead Bay, near Weymouth.

6. *Corbis concinna*, n. sp. plate 9, fig. 10.—Shell ventricose, angulated and compressed anteriorly; umbones small, compressed, submesial; posterior margin arcuated; antero-superior border straight, truncated in front, the surface ornamented by closely arranged somewhat irregular lines of growth, interrupted by a few distant prominent concentric ridges; the lines of growth decussated by exceedingly minute longitudinal striæ. Length one third more than the breadth. Diameter through both the valves ½ inch.

Locality—Kimeridge clay, near Weymouth.

7. *Astarte Thompsonii*, n. sp. plate 4, fig. 3.—Shell flatly convex, transversely elliptical; surface comparatively smooth in the young state, irregularly furrowed as it increases in size, and marked with numerous lines of growth; umbones small, interior: lunule moderately deep, ovately lanceolate; inner margin crenated. This species is allied to *A. obliqua*, but it is much less oblique.

Locality—Coral rag, Osmington, near Weymouth.

8. *Astarte modiolaris*, Lam.; var. plate 4, fig. 4.—The Shell figured appears to be identical with the *A. modiolaris*, Lam., from the Inferior Oolite of Bayeux, &c., excepting that they are uniformly much larger.

9. *Opis corallina*, n. sp. plate 4, fig. 10.—More tumid than *O. similis*, Phil, and with a larger lunule; it is also less elongated than *O. similis*, Sow.

Locality—Coral rag, near Sandsfoot Castle, Weymouth.

10. *Natica corallina*, n. sp. plate 5, fig. 2.—Shell ovate, globose; spire prominent; volutions five to six, somewhat convex, posteriorly depressed or tabulate; body-whorl large and ventricose; aperture somewhat ovate. Only casts occur. The species is allied to *Natica hemisphœrica*. Roemer sp. nord oolith, page 156, plate 10, fig. 9.

Locality—Coral rag, near Weymouth.

11. *Trigonia clavellata*, plate 2, fig. 3.—No accurate figure of this elegant species of trigonia has before appeared. It is not the *clavellata* of Sowerby. *T. clavellata* of Parkinson is the nearest approach to it, but if the Weymouth Oxford clay species be intended, it is badly drawn, and the author is silent as to the formation or locality.

Locality—Oxford clay, Weymouth.

12. *Cerithium Damonis*, n. sp. Lyc. fig. 18.—Shell elongated; volutions eight to nine, slightly convex, narrow, their height being only half the dimensions of their lateral diameter, deeply constricted at their junctions: tubercles in two rows equal, regular, very prominent, distinct, from thirteen to fifteen in volution. Aperture apparently small, canal short and not recurved. Length ten lines, diameter three lines.

From the Oxford clay, north of Weymouth.

I am indebted to my friends, Prof. Morris and Dr. Lycett, for the descriptions of the above new species.

LIST OF SHELLS COLLECTED ON THE WEYMOUTH COAST:

Named in accordance with the "British Mollusca," by Forbes and Hanley.

The greater portion of the list is made up of deep-water species, which are only to be procured by dredging.

Montagu, in his *Testacea Britannica*, 1803, refers several species to the coast of Weymouth, on the information of Mr. Bryer, that in no authenticated instance have since been found either here or on any other part of the British coast. Some of these are well-known West Indian species; but Montagu having regarded them as native, they have been inserted in the Pulteney Catalogue,* as well as in other publications; but in the "British Mollusca," by Forbes and Hanley, they are considered as exotic, and accordingly expunged from the list of British shells.

The common shells are denoted by the prefix 1; the fig. 2 denotes those which are less common, and 3 those which are rare.

This does not, however, indicate their general rarity, but only as applied to Weymouth, and even there is not permanent. From local causes, shells change their ground, and for a time disappear.

3 Teredo navalis.
3 Xylophaga dorsalis.
1 Pholas dactylus.
2 Pholas parva.
2 Pholas candida.
3 Pholadidea papyracea.
2 Gastrochæna modiolina.
2 Saxicava Arctica.
2 Saxicava rugosa.
2 Venerupis Irus.

* A Catalogue of the Natural History of the County of Dorset, by Sir W. Pulteney, F.R.S., published 1798, as an appendix to Hutchins' 'History of Dorset, 2nd edition.' The above catalogue, though imperfect when compared to more recent observations, contains much original and valuable information.

2 Mya truncata.
1 Corbula nucleus.
3 Sphænia Binghami.
3 Pandora rostrata.
2 Pandora obtusa.
3 Lyonsia Norvegica.
3 Thracia phaseolina.
3 Thracia villosiuscula.
3 Thracia pubescens.
3 Thracia convexa.
3 Thracia distorta.
3 Cochlodesma prætenue.
2 Solen marginatus.
1 Solen siliqua.
1 Solen ensis.
2 Solen pellucidus.
2 Ceratisolen legumen.
3 Solecurtus coarctatus.
2 Psammobia vespertina.
1 Psammobia Ferroensis.
3 Psammobia tellinella.
3 Diodonta fragilis.
2 Tellina crassa.
2 Tellina donacina.
2 Tellina incarnata.
1 Tellina tenuis.
1 Tellina fabula.
1 Tellina solidula.
2 Syndosmya alba.
3 Syndosmya prismatica.
2 Syndosmya tenuis.
1 Scrobicularia piperata.
1 Donax anatinus.
3 Donax politus.
3 Mactra solida.
2 Mactra truncata.
2 Mactra elliptica.
2 Mactra subtruncata.
2 Var. subtruncata.
1 Mactra stultorum.
2 Var. cinerea.
2 Lutraria elliptica.
3 Lutraria oblonga.
2 Tapes decussata.
1 Tapes pullastra.
1 Tapes virginea.
2 Tapes aurea.
2 Venus verrucosa.
3 Venus casina.
1 Venus striatula.
2 Var. gallina.
2 Venus fasciata.
2 Venus ovata.
2 Artemis exoleta.
1 Artemis lincta.
2 Lucinopsis undata.
2 Cyprina Islandica.
3 Cardium aculeatum.
2 Cardium echinatum.
2 Cardium rusticum.
1 Cardium edule.
2 Cardium nodosum.
3 Cardium fasciatum.
2 Cardium pygmæum.
1 Cardium Norvegicum.
3 Lucina borealis.
2 Lucina flexuosa.
3 Lucina leucoma.
3 Diplodonta rotundata.
3 Montacuta ferruginosa.
3 Turtonia minuta.
2 Kellia suborbicularis.
2 Kellia rubra.
3 Lepton squamosum.
3 Galeomma Turtoni.
1 Mytilus edulis.
2 Modiola tulipa.
2 Modiola barbata.

2 Crenella discors.
2 Crenella marmorata.
1 Nucula nucleus.
2 Nucula nitida.
2 Nucula radiata.
3 Leda caudata.
1 Arca lactea.
2 Pectunculus glycimeris.
2 Pinna pectinata.
3 Lima Loscombii.
1 Pecten varius.
2 Pecten pusio.
2 Pecten tigrinus.
2 Pecten maximus.
1 Pecten opercularis.
2 Var. lineatus.
1 Ostrea edulis.
1 Anomia ephippium.
2 Var. squamula.
2 Anomia aculeata.
3 Anomia patelliformis.
2 Chiton gracilis.
2 Chiton fascicularis.
3 Chiton discrepans.
2 Chiton ruber.
1 Chiton cinereus.
2 Chiton asellus.
3 Chiton cancellatus.
2 Chiton lævis.
1 Patella vulgata.
2 Patella pellucida.
2 Acmea virginea.
2 Dentalium entalis.
3 Dentalium Tarentinum.
2 Pileopsis Hungaricus.
2 Calyptrea Sinensis.
2 Fissurella reticulata.
2 Emarginula reticulata.
2 Emarginula rosea.
1 Trochus ziziphinus.
2 Var. Lyonsii.
2 Trochus granulatus.
2 Trochus exiguus.
2 Trochus striatus.
1 Trochus Montagui.
1 Trochus tumidus.
1 Trochus cinerarius.
1 Trochus umbilicatus.
1 Trochus Magus.
2 Trochus lineatus.
1 Phasianella pullus.
Adeorbis subcarinatus, (doubtful.)
2 Littorina neritoides.
1 Littorina littorea.
1 Littorina rudis.
2 Littorina patula.
1 Littorina tenebrosa.
1 Littorina littoralis.
2 Lacuna pallidula.
3 Lacuna puteolus.
2 Lacuna vincta.
2 Lacuna crassior.
3 Rissoa striatula.
3 Rissoa crenulata.
3 Rissoa punctura.
2 Rissoa costata.
2 Rissoa striata.
1 Rissoa parva.
1 Var. interrupta.
2 Rissoa costulata.
2 Rissoa rufilabrum.
1 Rissoa labiosa.
2 Rissoa inconspicua.
2 Var. vittata.
3 Rissoa semistriata.
1 Rissoa cingillus.
2 Var. rupestris.

3 Rissoa fulgida.
3 Rissoa littorea, in brackish water.
1 Rissoa ventrosa, in brackish water.
2 Rissoa ulvæ.
2 Skenea planorbis.
1 Turritella communis.
2 Turritella cornea.
3 Cœcum trachea.
Cœcum glabrum, doubtful.
2 Aporrhais pes-pelicani.
2 Cerithium reticulatum.
3 Cerithium adversum.
3 Scalaria communis.
3 Scalaria clathratula.
3 Stylifer Turtoni.
2 Eulima polita.
3 Eulima subulata.
3 Eulima bilineata.
3 Chemnitzia elegantissima.
3 Chemnitzia rufa.
3 Odostomia conoidea.
3 Odostomia plicata.
3 Odostomia eulimoides.
2 Odostomia pallida.
2 Truncatella Montagui, in brackish water.
3 Otina otis.
2 Natica monilifera.
2 Natica nitida.
2 Velutina lævigata.
3 Lamellaria perspicua.
3 Lamellaria tentaculata.
3 Cerithiopsis tuberculare.
1 Murex erinaceus.
3 Murex corallinus.
3 Lachesis minima.
1 Purpura lapillus.
1 Nassa reticulata.
2 Nassa incrassata.
2 Nassa pygmea.
1 Buccinum undatum.
2 Fusus Islandicus.
3 Fusus antiquus.
3 Trophon muricatus.
2 Mangelia turricula.
2 Mangelia rufa.
3 Mangelia purpurea.
3 Mangelia linearis.
3 Mangelia gracilis.
2 Mangelia nebula.
2 Var. lævigata.
3 Mangelia striolata.
3 Mangelia costata.
3 Mangelia septangularis.
1 Cypræa Europæa.
3 Ovula patula.
3 Marginella lævis.
3 Cylichna cylindracea.
2 Cylichna truncata.
2 Cylichna obtusa.
3 Amphisphyra hyalina.
2 Tornatella fasciata.
2 Akera bullata.
2 Bulla hydatis.
2 Scaphander lignarius.
2 Philine aperta.
3 Philine catena.
2 Aplysia hybrida.
3 Conovulus bidentatus.
3 Conovulus denticulatus.
2 Conovulus albus.

Marine mollusca are assigned to four zones; viz.:—

1. Littoral zone, or tract lying between the tide-marks.
2. Lamminarian zone, extending from low-water mark to 15 fathoms.
3. Coralline zone, from 15 to 50 fathoms.
4. Deep-sea coral zone, from 50 to 100 fathoms and upwards.

Manuscript Note of the late Professor Edward Forbes, made during his Residence at Lulworth, in the Year 1849.

Contents of Williams' dredge in 15 fathoms off Lulworth Cove, 8th Nov. 1849.

Mollusca.

Buccinum undatum.
Trochus ziziphinus.
Trochus tumidus.
Trochus magus.
Acmea virginea.
Emarginula rosea.
Turritella communis.
Chiton cinereus.
Chiton lævis.
Chiton fasicularis.
Pecten maximus.
Pecten opercularis.
Pecten varians.
Pecten obsoletus (tigrinus).
Ostrea edule.
Anomia ephippium.
Anomia squamula.
Arca lactea.
Nucula nucleus.
Pectunculus pilosus.
Venus casina.
Venus ovata.
Tapes virginea.
Kellia suborbicularis.
Saxicava rugosa.
Cardium levigatum.
Pleurobranchus.
Ascidia intestinalis, and two species.
Cynthia tesselata, and four species.

Echinodermata—Crustacea—Zoophytes, &c.

Ophiocoma rosula.
Pagurus Bernhardus.
Pinnotheres.
Actinia.
Balanus.
Sponge, three species.
Lepralia.
Millipora.
Sertularia abietina.

LIST OF THE LAND AND FRESHWATER SHELLS OF GREAT BRITAIN,

Of which those found in the neighbourhood of Weymouth are printed in *Italics*.

Cyclas rivicola.
Cyclas cornea.
Cyclas caliculata.
Cyclas lacustris.
Cyclas pallidum.
Cyclas pisidioides.
Pisidium obtusale.
Pisidium pusillum.
Pisidium cinereum.
Pisidium nitidum.
Pisidium Henslowianum.
Pisidium pulchellum.
Pisidium amnicum.
Unio tumidus.
Unio pictorum.
Unio margaritiferus.
Anodonta cygnea.
Dreissina polymorpha.
Neritina fluviatilis.
Paludina Listeri.
Paludina vivipara.
Bithinia tentaculata.
Bithinia Leachii.
Valvata piscinalis.
Valvata cristata, (rare).
Assiminea Grayana.
Arion empiricorum.
Arion flavus.
Arion hortensis.
Limax agrestis.
Limax cinereus.
Limax arborum, (rare).
Limax flavus.
Limax brunneus.
Limax tenellus.
Limax Sowerbii, (rare).
Limax gagates.
Testacella haliotoidea.
Vitrina pellucida.
Vitrina Draparnaldi.
Zonites cellarius.
Zonites alliarius.
Zonites nitidulus.
Zonites purus.
Zonites radiatulus.
Zonites nitidus.
Zonites excavatus, (rare).
Zonites crystallinus.
Helix aperta.
Helix aspersa.
Helix pomatia.
Helix arbustorum.
Helix Cantiana.
Helix Carthusiana.
Helix nemoralis.
  Var. hortensis.
  Var. hybrida.
Helix pisana.
Helix virgata.
  Var. alba.

Helix caperata.
Helix ericetorum.
Helix obvoluta.
Helix lapicida.
Helix rufescens.
Helix hispida.
Var. depilata.
Var. concinna.
Helix revelata.
Helix sericea.
Helix lamellata.
Helix aculeata.
Helix fulva.
Helix fusca, (rare).
Helix pulchella.
Helix rotundata.
Helix umbilicata.
Helix pygmæa.
Bulimus acutus.
Bulimus Lackhamensis.
Bulimus obscurus.
Bulimus Goodalli.
Pupa umbilicata.
Pupa muscorum.
Pupa Anglica.
Pupa secale.
Pupa edentula.
Pupa minutissima.
Pupa pygmea.
Pupa substriata.
Pupa antivertigo.
Pupa pusilla.
Pupa Venetzii.
Balea fragilis.
Clausilia laminata.
Clausilia biplicata.
Clausilia plicatula.
Var. Mortiletti.
Clausilia nigricans.
Zua lubrica.
Azeca tridens.
Achatina acicula.
Succinea putris.
Var. gracilis.
Var. intermedia.
Succinea oblonga.
Physa fontinalis.
Physa hypnorum.
Planorbis corneus.
Planorbis albus.
Planorbis glaber.
Planorbis nautileus.
Planorbis carinatus.
Planorbis marginatus.
Var. rhombeus.
Planorbis vortex.
Planorbis spirorbis.
Planorbis contortus.
Planorbis nitidus.
Planorbis lacustris.
Limneus pereger.
Var. ovata.
Var. lineata.
Limneus Burnetti.
Limneus auricularius.
Var. acutus.
Limneus stagnalis.
Var. fragilis.
Limneus truncatulus.
Limneus glaber, (rare).
Limneus palustris.
Limneus glutinosus.
Limneus involutus.
Ancylus fluviatilis.
Ancylus oblongus.
Carychium minimum.
Cyclostoma elegans.
Acme lineata.

LIST OF CRUSTACEA FOUND ON THE WEYMOUTH COAST,

Named in accordance with Bell's "British Crustacea."

Stenorynchus phalangium (*Edwards*)—Long-legged spider crab.
Stenorynchus tenuirostris (*Bell*)—Slender spider crab.
Achæus cranchii (*Leach*)—Cranch's spider crab.
Inachus Dorsettensis (*Leach*)—Scorpion spider crab.
Inachus dorynchus (*Leach*)—Leach's spider crab.
Pisa tetraodon (*Leach*)—Four-horned spider crab.
Hyas araneus (*Leach*)—Great spider crab.
Hyas coarctatus *Leach*)—Contracted spider crab.
Maia squinado (*Latr.*)—Spinous spider crab.
Eurynome aspera (*Leach*)—Strawberry crab.
Cancer pagurus (*Linn*)—Great crab.
Pilumnus hirtellus (*Leach*)—Hairy crab.
Carcinus Mænas (*Leach*)—Common shore crab.
Portumnus variegatus (*Leach*)—Pennant's swimming crab.
Portunus puber (*Leach*)—Velvet swimming crab.
Portunus arcuatus (*Leach*)—Arch-fronted swimming crab.
Portunus depurator (*Leach*)—Cleanser swimming crab.
Portunus pusillus (*Leach*)—Dwarf swimming crab.
Portunus Henslowii (*Leach*)—Henslow's swimming crab.
Pinnotheres pisum (*Latr.*)—Pea crab.
Gonoplax angulata (*Leach*)—Angular crab.
Ebalia Pennantii (*Leach*)—Pennant's nut crab.
Ebalia Bryerii (*Leach*)—Bryer's nut crab.
Ebalia Cranchii (*Leach*)—Cranch's nut crab.
Atelecyclus heterodon (*Leach*)—Circular crab.
Corystes cassivelaunus (*Leach*)—Masked crab.
Pagurus Bernhardus (*Fabr.*)—Common hermit crab.
Pagurus Prideauxii (*Leach*)—Prideaux's hermit crab.
Pagurus cuanesis (*Thompson*)—Drummond's hermit crab.
Pagurus lævis (*Thomson*)—Smooth hermit crab.
Pagurus Forbesii (*Bell*)—Rough-clawed hermit crab.

Pagurus Dilwynii (*Sp. Bate*)—Dilwyn's hermit crab.
Porcellana platycheles (*Lam*)—Hairy porcelain crab.
Porcellana longicornis (*M. Edw.*)—Minute porcelain crab.
Galathea squamifera (*Leach*)—Scaly galathea.
Galathea strigosa (*Fabr.*)—Spinous galathea.
Palinurus vulgaris (*Latr.*)—Common spiny lobster.
Callianassa subterranea (*Leach*)—Mud burrower.
Gebia stellata (*Leach*)—Mud borer.
Gebia deltura (*Leach*)—Larger mud borer.
Axius stirynchus (*Leach*)—Burrowing shrimp.
Astacus fluviatilis (*Leach*)—Common river cray fish.
Homarus vulgaris (*M. Edw.*)—Common lobster.
Crangon vulgaris (*Fabr.*)—Sand shrimp.
Crangon fasciatus (*Risso*)—Banded shrimp.
Crangon spinosus (*Leach*)—Spinous shrimp.
Crangon sculptus (*Bell*)—Sculptured shrimp.
Crangon trispinosus (*Hailstone*)—Three-spined shrimp.
Alpheus ruber (*M. Edw.*)—Edward's red shrimp.
Nika edulis (*Risso*)—Risso's shrimp.
Athanas nitescens (*Leach*)—Montagu's shrimp.
Hippolyte varians (*Leach*)—Varying hippolyte.
Hippolyte Cranchii (*Leach*)—Cranch's hippolyte.
Hippolyte Thompsoni (*Bell*)—Thompson's hippolyte.
Hippolyte Whitei (*Thompson*)—White's hippolyte.
Hippolyte Yarrellii (*Thompson*)—Yarrell's hippolyte.
Hippolyte Grayana (*Thompson*)—Gray's hippolyte.
Hippolyte Mitchelli (*Thompson*)—Mitchell's hippolyte.
Pandalus annulicornis (*Leach*)—Ring-horned shrimp.
Palæmon serratus (*Fabr.*)—Common prawn.
Palæmon squilla (*Fabr.*)—White prawn.
Palæmon varians (*Leach*)—Varying prawn.
Palæmon Leachii (*Bell*)—Leach's pawn.
Mysis chamæleon (*J. V. Thompson*)—Thompson's opossum shrimp.
Mysis vulgaris (*J. V. Thompson*)—Common opossum shrimp.
Mysis Griffithsiæ (*Bell*)—Griffith's opossum shrimp.
Squilla Desmarestii (*Risso*)—Desmarest's mantis crab.

For Collectors who name after the British Museum Catalogue, the following Synonyms are given, all of which are included in the foregoing list.

Stenorynchus rostratus (*Brit. Mus. Cat.*)—Slender-legged crab.

Arctopsis tetraodon (*Brit. Mus. Cat.*)—Four-horned spider crab.

Portumnus latipes (*Brit. Mus. Cat.*)—Pennant's swimming crab.

Portunus rondeletii (*Brit. Mus. Cat.*)—Arch-fronted swimming crab.

Ebalia tuberosa (*Brit. Mus. Cat.*)—Pennant's nut crab.

Ebalia tumefacta (*Brit. Mus. Cat.*)—Bryer's nut crab.

Ebalia Cranchii (*Brit. Mus. Cat.*)—Cranch's nut crab.

Atelecyclus septem-dentatus (*Brit. Mus. Cat.*)—Face crab.

Palinurus homarus (*Brit. Mus. Cat.*)—Spiny lobster.

Potamobius astacus (*Brit. Mus. Cat.*)—Cray fish.

Astacus gammarus (*Brit. Mus. Cat.*)—Common lobster.

Pandalus Montagui (*Brit. Mus. Cat.*)—Ring-horned shrimp.

A LIST OF MARINE ALGÆ FOUND ON THE WEYMOUTH COAST,

Named in accordance with Harvey's "Manual."

Halidrys siliquosa.
Cystoseira ericoides.
Cystoseira granulata.
Cystoseira fœniculacea.
Cystoseira fibrosa.
Pycnophycus tuberculatus.
Fucus vesiculosus.
Fucus serratus.
Fucus nodosus.
Fucus canaliculatus.
Himanthalia lorea.
Desmarestia ligulata.
Desmarestia aculeata.
Desmarestia viridis.
Arthrocladia villosa.
Sporochnus pedunculatus.
Laminaria digitata.
Laminaria bulbosa.
Laminaria saccharina.
Laminaria Phyllitis.
Laminaria fascia.
Chorda filum.
Chorda lomentaria.
Cutleria multifida (Portland).
Haliseris polypodioides.
Padina pavonia.
Taonia atomaria, (rare).
Dictyota dichotoma.
Stilophora rhizoides.
Dictyosiphon fœniculaceus.
Punctaria latifolia.
Punctaria plataginea.
Punctaria tenuissima.
Asperococcus compressus.
Asperococcus Turneri.
Asperococcus echinatus.
Litosiphon pusillus.
Litosiphon Laminariæ.
Mesogloia vermicularis.
Mesogloia Griffithsiana.
Mesogloia virescens.
Elachistea fucicola.
Elachistea flaccida, (com.).
Cladostephus verticellatus.
Cladostephus spongiosus.
Sphacelaria cirrhosa, (com.).
Ectocarpus siliculosus, (com.).
Ectocarpus Hincksiæ.
Ectocarpus tomentosus.
Ectocarpus litoralis.
Ectocarpus granulosus.
Ectocarpus brachiatus.
Myriotrichia clavæformis.
Myriotrichia filiformis.
Rhodomela subfusca, (com.).
Rytiphlæa pinastroides.
Rytiphlea thnyoides, (Port.).
Rytiphlea fruticulosa.
Polysiphonia urceolata.
Polysiphonia formosa.

Polysiphonia fibrata.
Polysiphonia Giffithsiana, (Portland).
Polysiphonia elongella.
Polysiphonia elongata.
Polysiphonia fibrillosa.
Polysiphonia Brodiæi.
Polysiphonia nigrescens.
Polysiphonia subulifera.*
Polysiphonia atro-rubescens.
Polysiphonia fastigiata.
Polysiphonia byssoides.
Dasya coccinea.
Bonnemaisonia asparagoides.
Laurencia pinnatifida.
Laurencia obtusa.
Chondria dasyphylla.
Chondria tenuissima.
Lomentaria ovalis.
Lomentaria kaliformis.
Chylocladia clavellosa.
Chylocladia Orcadensis.
Chylocladia articulata.
Champia parvula.
Corallina officinalis.
Corallina elongata.
Jania rubens.
Jania corniculata.
Wormskioldia sanguinea.
Wormskioldia sinuosa.
Wormskioldia alata.
Wormskioldia Hypoglossum.
Wormskioldia ruscifolia.
Nitophyllum punctatum.
Nitophyllum Hilliæ, (Port.).
Nitophyllum Bonnemaisonni, (Portland).
Nitophyllum Gmelini, (Port.).
Nitophyllum laceratum.
Nitophyllum versicolor, (rare, Portland).
Plocamium coccineum.
Rhodophyllis bifida.
Callophyllis lacinata.
Calliblepharis ciliata.
Calliblepharis jubata.
Rhodymenia palmata.
Rhodymenia palmetta.
Sphærococcus coronopifolius.
Gracilaria compressa.
Gracilaria compressa.
Gracilaria confervoides.
Cystoclonium purpurascens.
Gelidium corneum.
Gigartina mamillosus.
Chondrus crispus.
Phyllophora rubens.
Phyllophora membranifolius.
Phyllophora palmettoides.
Ahnifeldtia plicata.
Polyides rotundus.
Furcellaria fastigiata.
Dumontia filiformis.
Halymenia ligulata.
Scinaia furcellata, (rare).
Kallymenia reniformis.
Schizymenia edulis.
Naccaria Wigghii.
Helminthora divaricata.
Ptilota plumosa.
Ceramium rubrum.
Ceramium botryocarpum.
Ceramium Deslongchampii, (Portland).

* Growing upon *Rytiphlæa pinastroides*—very rare.

Ceramium diaphanum.
Ceramium gracillimum, (Portland).
Ceramium strictum, (Port.).
Ceramium nodosum.
Ceramium fastigiatum.
Ceramium echionotum.
Ceramium acanthonotum.
Ceramium ciliatum.
Spyridia filamentosa.
Griffithsia equisetifolia.
Griffithsia corallina.
Griffithsia setacea.
Wrangelia multifida.
Callithamnion plumula, (common).
Callithamnion Turneri.
Callithamnion tetragonum.
Callithamnion brachiatum.
Callithamnion tetricum.
Callithamnion Hookeri.
Callithamnion byssoideum.
Callithamnion polyspermum.
Callithamnion floridulum.
Callithamnion Daviesii.
Codium adhærens, (rare).
Codium tomentosum.
Bryopsis plumosa.
Bryopsis hypnoides, (Port.).
Cladophora pellucida.
Cladophora rectangularis.
Cladophora Hutchinsiæ.
Cladophora diffusa.
Cladophora rupestris.
Cladophora lætevirens.
Cladophora flexuosa.
Cladophora gracilis.
Cladophora refracta, (Port.).
Cladophora albida.
Cladophora lanosa, (Port.).
Cladophora uncialis.
Cladophora arcta, (Portland).
Cladophora glaucescens.
Conferva linum, (Backwater).
Conferva ærea.
Enteromorpha compressa.
Ulva latissima.
Ulva Lactuca.
Ulva Linza.
Porphyra laciniata.
Porphyra vulgaris.
Bangia fusco-purpurea, (Port.)
Rivularia atra.
Rivularia nitida.
Calothrix confervicola.
Lyngbya majuscula.
Lyngbya Carmichaelii, (Port.)

RARER PLANTS TO BE OBSERVED NEAR WEYMOUTH.

Adonis autumnalis—Cornfields at Portland.
Papaver hybridum—Near Wyke.
Glaucium luteum—Stony Beach.
Fumaria capreolata—Lane at Chesil, Portland.
Cochlearia danica—Chesil Beach, by the road.
Cakile maritima—Sandy shore.
Arabis hirsuta—Rocks at Portland.
Silene anglica—Very sparingly, near the sluice, Lodmoor.
Silene inflata—Chesil Beach (Forbes), towards Abbotsbury.
Linum angustifolium—Near the Ferry-bridge; Backwater banks, near gas-works.
Geranium lucidum—Rocks at Portland.
Geranium columbinum—Ditto.
Medicago maculata—Cliffs, &c., in several places.
Medicago denticulata—Ditto.
Trifolium ornithopodioides—Chesil Bank, close to Portland, and at Portland.
Trifolium maritimum—By the Backwater and the cliffs.
Trifolium scabrum—Sandy shore, &c.
Vicia gracilis—Cornfields at Portland.
Vicia augustifolia—Cliffs towards Sandsfoot Castle.
Vicia lutea—Field in the cliff near Sandsfoot Castle; stony beach at Lodmoor.
Lathyrus aphaca—Fields, &c., at Portland (abundant); also near Wyke.
Pisum maritimum—Chesil Bank, opposite Wyke.
Rosa spinosissima—Portland.
Petroseliuum segetum—Hedges (not uncommon).
Sison amomum—Hedges (frequent).
Bupleurum tenuissimum—Field by Backwater on the west side beyond the gas-works; also near the sluice, Lodmoor.
Œnanthe pimpinelloides—Moist meadows, &c. (frequent).

Silaus pratensis—Moist meadows, &c. (frequent).
Pastinaca sativa—Fields and roadsides.
Torilis infesta—Roadsides.
Smyrnium olusatrum—Cliffs near the pier.
Eryngium maritimum—Chesil Bank, and by Ferry-bridge.
Rubia peregrina—Rocks at Portland.
Asperula Cynanchica—Portland.
Fedia auricula—Ditto.
Prenanthes muralis—Ditto.
Carduus nutans (white flowers)—Portland, near the upper church.
Carduus marianus—Portland.
Cichorium intybus—Cornfields and roadsides.
Conyza squarrosa—Portland.
Solidago virgaurea—Ditto.
Senecio sylvaticus—Cliffs by Backwater.
Aster tripolium—Salt marshes.
Pyrethrum maritimum—Ditto.
Campanula glomerata—Maumbury, near Dorchester.
Campanule hybrida—Portland, in cornfields.
Gentiana amarella—Maumbury, near Dorchester.
Erythræa pulchella—Portland cliffs, and by Backwater.
Convolvulus soldanella—Chesil Bank, near the road.
Borago officinalis—Portland.
Linaria spuria—At Lodmoor and road to Radipole.
Linaria elatine—Fields (rare).
Galeopsis ladanum—Cornfields at Portland.
Orobanche elatior—Maumbury, near Dorchester.
Orobanche minor—Sparingly at Portland.
Plantago maritima—Marshes, near the Backwater.
Glaux maritima—Ditto.
Salsola kali—Sands, near Ferry-bridge.
Chenopodium maritimum—Salt mashes.
Chenopodium fruticosum—Chesil Bank, west of the bridge
Chenopodium ficifolium—Near the Backwater (very rare).
Chenopodium murale—Waste ground.
Atriplex portulacoides—Marshes by Backwater.
Atriplex littoralis—Chesil Bank.
Beta maratima—Salt marshes and shore.

Salicornia herbacea—Marshes by Backwater.
Rumex pulcher—Roadsides (frequent).
Thesium linophyllum—Cliffs by Sandsfoot sands (sparingly).
Euphorbia paralias—Chesil Bank, near the road.
Euphorbia Portlandica—Portland and Chesil Bank.
Euphorbia amygdaloides—Portland.
Mercurialis annua—Waste ground.
Triglochin maritimum—Marshes, Radipole, &c.
Iris fœtidissima—Hedges (frequent).
Tamis communis—Hedges.
Ruscus aculeatus—Roadside, near Broadway.
Ruppia maritima—Salt marsh ditches, near the sluice.
Zannichellia palustris—Ditto.
Juncus acutus—Shore of the Backwater.
Scirpus maritimus—Near Radipole, &c.
Scirpus savii—at Portland.
Carex arenaria—Sands, near Ferry-bridge.
Alopecurus bulbosus—Salt marshes.
Ammophila arundinacea—Sandy shore.
Phleum arenarium—Ditto.
Gastridium lendigerum—Backwater cliffs, Jordan Hill cliffs.
Poa distans—Salt marshes, by Backwater.
Poa maritima—Ditto.
Poa procumbens—Ditto.
Festuca bromoides—Backwater cliffs.
Festuca uniglumis—Sandy field near Ferry-bridge, and by the road near Chesil Bank.
Avena fatua—Fields and cliffs (frequent).
Hordeum pratense—Fields, &c. (frequent).
Hordeum maritimum—Lane near the gas-works.
Triticum loliaceum—Road near Sandsfoot Castle, &c.
Triticum junceum—Sandy coast by Ferry-bridge.
Brachypodium pinnatum—Cliffs, &c. (plentiful).
Rottbollia incurvata—Salt marshes (abundant.
Ophioglossum vulgare—(F.) Chesil Beach, towards Abbotsbury.
Hyacinthus—(?) Under-cliff, Portland.
Sellis pirennis—Ditto.

In the Island of Portland the root of the common *Arum maculatum* is prepared and eaten, and a good quantity was at one time sold, under the name of Portland arrow-root, at 1*s.* 6*d.* per lb. Since the reduction in the price of the arrowroot of commerce, it has been but little used.

Crithmum maritimum.—On the Chesil Bank, and on the cliffs at Portland, where it is a herb in much request as a pickle.

Manuscript Note of Professor E. Forbes.

VARIETIES OF VIOLA CANINA OBSERVED IN PORTLAND.

1. Large normal form in bushy places. Flowers very purple — sepals lanciolate — spurs rather stout — palea purple—radical leaves large, long, slender: all leaves more or less slightly hairy.

2. Smaller form. Similar but more contracted—leaves very slightly hairy—cordate—radical leaves not conspicuously large—spurs large, pale, rarely purple.

3. Small cæspetose. Flowers very large in proportion to leaves—spurs mostly large—purple-blue—purple rarely, or often yellowish or white—leaves all small, except radicals—smooth crenulate.

LIST OF FERNS GROWING IN THE NEIGHBOURHOOD OF WEYMOUTH.

I am indebted to J. Daniels, Esq., late of Wool, for the identification of several of the rarer species, as also for the habitats of others. The nomenclature is that of Newmau's "History of British Ferns," Van Voorst, 1854.

Blechnum spicant—Hard Fern. Common in hedges and woods.
Eupteris aquilina—Eagles' Wing or common brake. Common everywhere.
Ctenoperis vulgaris—Common Polypody. Portland.
Gymnocarpium phegopteris—Beach Fern, *rare*. Heffleton Woods.
Cystoperis fragilis—Brittle Fern. Not uncommon.
Polystichum aculeatum—Prickly Fern. Common in hedges.
Polystichum angulare—Willdinow's Fern.
Hemestheum Thelypteris—Marsh Fern. Wool Heath.
Lastrea montana—Mountain Fern, *rare*. Wool Heath and Portland.
Lophodium Fœnescii—Bree's Fern. In woods N. E. of Weymouth.
Lophodium multiflorum—Roth's Fern. Do.
Lophodium spinosum—Withering's Fern. Do.
Lophodium rigidum—Rigid Fern. On the road to Bere in a swamp.
Dryopteris (*Lastrea*) *filix mas*—Male Fern. Common, Portland.
Dryopteris Lastrea) *f. m.*—*var. affinis, rare.*
Pseudathyrium alpestre—*rare.* E. Lulworth. Newman says it is only found British in the Scotch mountains.
Athyrium filix fœmina—Lady Fern. Common.
Asplenium marinum—Sea Spleenwort, *rare*. Portland and Lulworth.
Asplenium trichomanes—Maiden Hair Spleenwort, common. Portland and Bindon Abbey.
Amesium ruta muraria—Wall rue, abundant. Portland and Wool.
Phyllitis scolopendrium—Harts' Tongue Fern. Abundant on Lookout and Portland.
Notolepeum ceterach—Scaly Spleenwort, *rare*. Wool and Portland.
Botrychium lunaria—Moonwort, *rare*.
Ophioglossum vulgatum—Adders' Tongue. Bindon Abbey.
Osmunda regalis—Flowering Fern. Bindon Abbey and Wareham.

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INDEX.

A SUPPLEMENT

TO THE

HANDBOOK TO THE GEOLOGY

OF

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